## DOCUMENT RESUME

ED 111 361 IR 002 415

TITLE Computing and the Decision Makers; Where Does Computing Fit in Institutional Priorities? Proceedings of the EDUCOM Spring Conference, April 17-18, 1974.
INSTITUTION Interuniversity Communications Council (EDUCOM), Princeton, N. J.
PUB DATE 74
NOTE 375p.
AVAILABLE FROM EDUCOM, P.O. Box 364, Princeton, New Jersey 08540 ($6.00 EDUCOM Members; $9.00 Others)

EDRS PRICE MF-$0.76 HC-$18.40 Plus Postage
DESCRIPTORS Computer Assisted Instruction; *Computers; Conference Reports; *Decision Making; Educational Development; *Governing Boards; Higher Education; *Institutional Administration; Management Information Systems; State Departments of Education; *Statewide Planning; *Time Sharing
IDENTIFIERS *EDUCOM

ABSTRACT

Proceedings of the EDUCOM 1974 Spring Conference are edited and collected under four topic headings related to questions of ever-tightening budgets and relationships between public institutions of higher education and state coordinating or governing boards. Aspects covered include the development of state-wide resources-sharing arrangements; the ways in which computing can be delivered; resource allocation within an institution; and computing for instruction. Addresses and papers are gathered into 21 subcategories of these four themes. Names and addresses of all conference participants are included in an appendix. (SK)

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# COMPUTING and the DECISION MAKERS

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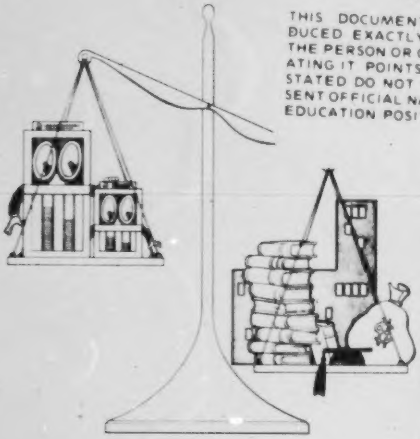

## WHERE DOES COMPUTING FIT IN INSTITUTIONAL PRIORITIES?

IR 002 415

PROCEEDINGS
of the
EDUCOM SPRING CONFERENCE

April 17-18, 1974

EDUCOM, The Interuniversity Communications Council, Inc.

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# Preface

Two of the most critical problems facing colleges and universities today are ever-tightening budgets and relationships between the public institutions of higher education and state coordinating or governing boards. The Spring 1974 EDUCOM Conference "Computing and the Decision Makers: Where Does Computing Fit in Institutional Priorities?" addressed these issues and others from the viewpoint of the administrator. For in decisions on questions of funding within an institution and on relationships with state coordinating agencies, it is the administrator who is responsible for institutional finances as well as computing who is the decision maker.

Developing four unique aspects of the conference theme, separate tracks of the conference included: the development of statewide resource sharing arrangements; the ways in which computing can be delivered; resource allocation within an institution; and computing for instruction. Designed as an opportunity for individuals with responsibility for computing within institutions to meet with the administrator who must allocate resources within the institutions, the conference drew a diverse audience including representatives from colleges, universities, educational service organizations and state coordinating boards.

Keynote addresses and papers presented in panels and workshops have been edited and collected in the following pages. Further information concerning any of the systems or applications described in these chapters can best be obtained by writing directly to the author of the presentation. The names and addresses of all conference participants are listed in an appendix.

On behalf of all the conferees, I want to extend sincere thanks to the conference chairman, Gerard P. Weeg, for the time and effort which he devoted to preparing such an outstanding program for the conference. Special thanks also go to conference program committee members E. Rex Krueger, Arthur Luehrmann, Dillon Mapother, Duane Spriestersbach and Charles Warlick.

*Henry Chauncey*

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# Introduction

The EDUCOM Spring 1974 Conference was intended to bring together high level decision makers and computer center directors to educate each other regarding the place of computing in institutional priorities. Structured panel and discussion sessions as well as informal sessions provided an opportunity for persons with similar responsibilities to exchange information. However, by bringing together the key decision makers and the advocates of the use of technology in higher education we hoped to encourage in a way not often accomplished within individual institutional settings, debate, understanding, and perhaps resolution, of some of the issues related to the incorporation of computing into regular institutional budgets and plans. Fair and rational decisions can be achieved about allocation of computing resources only if the organizational issues as well as the costs and benefits of the technologies are understood by all parties.

These proceedings are structured to reflect the four tracks of the conference: resource allocation within an institution; statewide planning; modes of delivery of computing services; and the use of computers for instruction. Beginning with a keynote presentation, each of the four parts of this volume include most of the papers presented in panels and workshops during the conference. Charles Mosmann's keynote presentation on statewide resource sharing arrangements includes observations based on his year-long study of Academic Computer Planning in North America which he has conducted under the sponsorship of EDUCOM. Chapters following the Mosmann presentation include case study style descriptions of existing resource sharing arrangements in the states and provinces.

Part II focuses on ways of delivering computing services within an institution. Keynoted by Leland Williams, Triangle Universities Computation Center, this portion of the volume includes presentations on delivery of computing via networks within and among institutions, and papers on various hierarchical arrangements which can be made within an institution.

Part III of this volume includes presentations on the allocation of resources within the university from the viewpoint of the president and other high level administrators. Keynoted by Ronald Roskens, Chancellor of the University of Nebraska at Omaha, papers in this portion of the book outline the factors which the president of an institution of higher education considers when allocating funds to computing and other activities within an institution. Viewpoints are expressed by representatives of colleges and universities of a range of size and mission.

Part IV of this volume, focusing on computing for instruction, includes papers which illustrate specific applications of computing for instruction in colleges and universities as well as comments on training faculty members to use computing in instruction and incentives which are necessary to incorporate computing into the regular curriculum. The keynote for this portion of the book reviews various ways in which computing can be used for instruction in the university.

A banquet address on computing activities in the U.S.S.R. presented by Don Aufenkamp of the National Science Foundation, provided a highlight for many conferees as well as a change of pace from the domestic focus of the presentations. Dr. Aufenkamp's presentation on computing activities in the U.S.S.R. appears as Chapter 21.

The 1974 Spring EDUCOM Conference did provide an opportunity for an exchange of views between administrators from colleges and universities who must weigh the allocation of resources to computing and other technologies against a myriad of other institutional needs, with the faculty and computer professionals responsible for computing services who are concerned that the full benefits of the application of these technologies be understood when budgets and institutional plans are made.

All of the speakers, workshop chairmen, and panel members at the conference contributed much time and effort to the program. Without their contributions the level of discussion and the wealth of information available at the conference and included in this volume would not have been possible.

*Gerard P. Weeg*
*Conference Chairman*

# PART I

## STATEWIDE SYSTEMS

# Chapter 1

## Statewide Systems

**by Charles J. Mosmann**

For the past twelve months, I have been engaged in a study of academic computer planning in the American states and Canadian provinces. Specifically, the study examines the extent to which planning for computing resources, and the execution of these plans, is taking place off campus, in multi-campus governing boards, in coordinating councils and boards of higher education, and in government agencies whose primary function is fiscal control rather than education. The report of this project, which includes some two dozen case studies, will be available in the fall of 1974[1].

Gratitude is due to the Exxon Education Foundation, which generously sponsored the project, and to EDUCOM, which provided the project a home. Without the freedom provided by these two organizations, nothing could have been done.

### ATTITUDES TOWARD STATE ACTION

In 1971 at the EDUCOM meeting in Philadelphia, a series of speakers and panels introduced many educators to a revolution in the way in which computing services might be provided for higher education. The growing viability of a number of alternatives to the traditional "one-campus/one-computer" concept was the major theme of that day's meetings.

Mini-computers, multi-campus systems, regional and national networks, specialized and discipline-oriented centers all appeared reasonable ways of providing some of the services higher education needed. Taken together, they promised to users the ability to select the services uniquely suited to satisfy their demands.

Many left that meeting with a feeling of exhilaration. New things were happening. It was a time of opening up, a time when old certainties disappeared and new opportunities emerged. This feeling of opening up persists and remains an essential characteristic of EDUCOM meetings: an awareness of a future in which we can bring to our campuses a rich variety of alternative forms of computation to support a wide variety of different purposes and different users.

In one speech at the Spring 1971 EDUCOM Conference, Robert Mautz described a scheme for statewide coordination of computing in Florida. While he did not proclaim "one-state/one-computer", he did advocate far fewer computers than one per campus and he did insist on the need for one single, integrated, and unified plan for computing in higher education in Florida. At that time, this too seemed part of the growing wealth of alternatives available to explore.

In 1973, correspondence with people in each of the states, Puerto Rico, and all but the smallest of the provinces of Canada and discussions, visits, and many thousands of pages of descriptive material reviewed for the study indicate that the feeling of opening up, of emerging richness, has been replaced on many campuses by one of closing in, a diminishing of options, and a loss of freedom. In many states, the range of alternatives has not been interpreted as a set among which the *user* should be allowed to decide, but one among which those responsible for the entire *system* of higher education should select, on behalf of the community of users.

The logic in these cases goes something like this: One: If there are many alternatives, one must be better than the rest. Two: Computing can be considered a utility, like water or electrical power. The question is, where can computing of satisfactory quality be acquired most economically. Three: The choice is between the small and inefficient and the large and efficient. Consideration of economy of scale compels us to select the latter. Conclusion: A single, large computer system on the model of a star network should be provided for all the colleges within a geographic area and under common control.

Perhaps the worst aspect of this argument is the fact that it encourages others to similar decisions. The "network bandwagon" is highly evident in state and provincial capitols and bureaucrats and administrators everywhere are scrambling to get on it. In nearly one-third of the sixty states and provinces, decision-makers are guided by an explicit plan for computing in higher education which has been generated at the provincial or state level. This plan determines what they will and will not do. In another third, such a plan is now under development. Almost all such plans explicitly call for the sharing of resources between campuses, usually by means of a network constructed specifically for this purpose. Only twenty states and provinces indicate that their public colleges and universities are totally responsible for decisions about computing.

The results of such plans, which often lead from coordination to cooperation and thence to consolidation, are liable to be less than a total success. Networks are not incapable of providing good service, quite the contrary, but some of the systems constructed with the explicit purpose of serving multiple educational institutions have been unsatisfactory. Furthermore, many of those currently in the planning stage give every indication of satisfying, once they are complete, neither the state agencies that insisted on their creation, nor the users they are expected to serve. They exhibit low quality service, high costs, and under-utilization.

The most common fallacy exhibited in state plans is the assumption that installing communications lines to an existing on-campus computer center makes a statewide or regional network. It does not. Without real efforts to provide guarantees of stability and quality, well documented applications programs and consulting services oriented to the naive and long-distance users, the customers at the outlying campuses will not take advantage of what is offered to them. Without a serious effort to make services accessible and to give the outlying users some influence over the policy and operation of the center, a center will naturally be monopolized by the on-campus users. In one state, for instance, three regional centers have been created. After nearly five years of operation, it now appears that at two of the centers, something less than five percent of the resources are being used off campus through the communications network.

Financial problems are not uncommon. In two states, regional centers have been established to replace on-campus computing centers. In both states, users now complain that they cannot afford to do computing, because services cost more at the new centers than at the smaller, on-campus centers they replaced. Both regional centers, by the way, were established with funding from the state governments; so users were not paying for the set-up costs. Since users also complain about the quality of the service, higher fees have not purchased better quality services. Financial problems have been caused by the unrealistic assumptions about what is possible in a relatively simple and straightforward computer center serving a large group of heterogeneous users.

The sheer difficulty of solving the technical problems has made some developers and planners blind to the problems of network management, financial control, and user service. In one of the first statewide systems, for instance, a network was imposed on a largely computerless group of colleges. It provided hardware service, but little incentive to the colleges to develop excellence or the imaginative use of computing in instruction. By forcing users to conform to the system, the network inhibited what it intended to promote. In another of the earliest state systems, so much effort and attention have been given to politics, argument and in-fighting that precious little intellectual resource has been left for the educational functions that ought to have been the object of the entire enterprise.

Some networks do work, and work very well. From the point of view of the user, the highly successful Dartmouth, Iowa and North Carolina systems are star networks. They *do* provide the best means for users at small institutions to catch up with the state of the art. These systems are engineered to serve this kind of user; many others are not. Few people in state capitols seem able to tell the difference. A worthwhile system for a geographically dispersed user community in education must exhibit a complex of characteristics, which may be very difficult to assure.

Designing a system to satisfy these requirements and the financial and political restrictions imposed by agencies in the capitol is a considerable task to impose on a group of designers or a planning task force. The necessary technical and managerial skills to carry it off do not exist on every campus or even in every state and province. Those states that have explicitly rejected the opportunity and the risk of creating a statewide system of coordination and consolidation (Arizona, Indiana, New Mexico, for instance) may be making a wiser choice than states attempting more than they can reasonably expect to achieve.

This may be too negative a point of view, but dangers and gentle warnings are often easily overlooked. There *is* much to be pessimistic about in the current state of planning in a large number of states and provinces, but this can change. If some positive change can be made in these planning efforts, the reasons for optimism are considerable. Improvement will not come by trying to make statewide coordination go away, or by trying to force computing back onto the campus, but by building systems that will work. A number of states and provinces are doing just that.

## EXEMPLAR SYSTEMS

The Minnesota Educational Computing Consortium (see Chapter 5) shows every indication of becoming an exciting development and a valuable model. The consortium which consists of primary, secondary, and vocational schools as well as higher education institutions, does not rely solely on a single monolithic computer center, but will support several systems serving different subsets of a large and heterogeneous community. Perhaps of greater significance, MECC has the enthusiastic acceptance of its major users.

SaskComp, the Crown Corporation that provides computing for all education and government in Saskatchewan, shows an imaginative approach to the difficult problem of providing resources to a small user community. Although the SaskComp operation is small in terms of people and money, it serves a user community widely spread geographically.

The ambitious effort in Ontario is to create a means of resource sharing without centralization and without loss of control by universities to government agencies.

North Carolina's success in providing computer-based instructional materials is well known. So is that of the University of Iowa and Iowa State University in providing statewide services without the involvement of statewide agencies.

Many efforts are underway to provide administrative services and systems from a coordinated and even centralized base. New York, New Jersey, Connecticut, Massachusetts and Quebec, among others are examples.

Before these innovations are even well established, examples of sharing on a wider basis still are evident: CONDUIT in the instructional area; an inter-provincial project in western Canada in administration, and the borrowing of administrative computing materials from Florida by New Jersey.

However, there is another aspect of the question which should be emphasized. At the 1973 meeting of the American Council on Education, Richard Millard, Director of Higher Education Services for the Education Commission of the States, said, "The fact is that unilateral, essentially autonomous decision making among post-secondary educational institutions and agencies is no longer possible. This is true of community colleges and of large complex universities, of local agencies, and of state and even federal ones as well." Greater control of education from off campus is an inescapable fact. Computer networks may be the first but will hardly be the only cases of resource sharing throughout systems of higher education.

Computing, in serving educational goals, must be expected to be part of education and to be governed the way education is governed. The trend toward centralization in the governance of higher education combines with technological developments that make long-distance computing possible. Thus any reasonable analysis of possible futures must conclude that a return to the one-campus/one-computer model of the 60's is just out of the question. The alternatives simply provide too many opportunities for both quality and economy of operation, opportunities that are too great to be foregone.

After all, the one campus/one computer model was far from perfect. Computing has not been well distributed in higher education, nor has it served all classes of users equally well, nor has it been universally well managed.

Colleges and universities have allowed, even encouraged, legislators and those responsible for state budgets to make some simplifying assumptions that are just not good enough any longer. Three assumptions in particular have been used frequently: One: The concept of the computer utility, which encourages people to believe that all computing is alike and every user wants the same thing. Two: The notion that computing has a life and purpose of its own, independent of the organization it serves, and that we can plan for it, budget for it, and organize it without consideration of the goals of the institution as a whole. Three: The idea that bigger is better.

All three of these notions were a great help in the struggle for the on-campus centralization of computing. However, they are coming back to haunt us in the present era of resource sharing between campuses. In planning for computing in higher education, educators must attempt to un-do these notions and replace them with a more realistic model.

First, institutions must define specific goals. Computing is a service function in the college or university. What it should do and what it should cost cannot be defined by the computer committee alone. These things depend on the educational, research, and service functions of the university, and need to be examined in the context of the priorities and alternatives of the institution as a whole.

Second, colleges and universities should make sure that plans have their foundation in a realistic analysis of the technology and where it may be going. Statewide or regional systems of resource sharing do not promise to be any more permanent a solution to computing needs than was the one-campus/one-computer model of the 60's. Whatever else may be said about them, the 80's will certainly be different.

Third, institutions need a realistic analysis of user needs, in terms of all dimensions of the services that are provided. Not only must hardware, software and documentation be considered, but also management functions and such important components as reliability and stability and convenience.

Finally, it is a not unreasonable goal to strive for meaningful cooperation between colleges and universities, for networks that *will* spread resources to the have-nots and that *will* enrich the opportunities available to those in a position to use them. Cooperation can emerge between institutions and should not have to be imposed on unwilling colleges by authoritarian governance.

## CONCLUSION

Resource sharing has been an object of some interest and effort in higher education for many years. However, because of geography (colleges and universities seem to be located so as to minimize interaction) it has usually been too difficult to be worth the cost. Besides being intellectual activities, instruction and research are physical and it is impractical to share physical resources over great distances. Thus only very limited sharing has ever been possible. Television has made the sharing of instruction possible but has done so only by attenuating its attractiveness and usefulness. A canned professor is just not as good as a live one. Current technology has not yet made it economical or convenient to share most library resources. Shelf space for a seldom used book is still cheaper than the manpower and technology and organization needed to share it. Computing, however, in its current stage of development, is uniquely a substance that *can* be shared.

If then institutions are the custodians of the first academic resource that can in fact be shared despite geography, and are the first agents to attempt such sharing on a large scale, it is no wonder that they are having trouble. There are no models upon which to build. In fact, educators may be constructing models that have importance and implication beyond our vision. The issues before us may be new but they will not long be unique. The policies colleges and universities establish, and the relationships and organizations they create and use will affect a growing circle of affairs throughout education in the years to come.

## REFERENCE

1. Mosmann, C. J., *Statewide Computing Systems: Coordinating Academic Computer Planning*, Marcel Dekker Inc., New York, 1974.

# Chapter 2

## Forms of Cooperation

### What is MECC?

**by Donald Henderson**

The Minnesota Educational Computing Consortium (MECC) is a new organization formed by all levels of education in the State of Minnesota under a legal agreement called a joint powers agreement. This agreement permits the new organization to have those powers that are shared in common by the cosigners of the agreement. The State systems which signed the joint powers agreement wer: the Community College System; State Department of Administration; State Department of Education; State College System; and the University of Minnesota System. The new organization is governed by a 16 member board of directors with two members representing each of the higher education systems, six members representing the State Department of Education, three members appointed by the Governor, and one appointed by the Commission of Administration. An advisory council, formed to advise the board and the MECC staff, includes eighteen members appointed by the various educational systems and selected from private education.

The MECC staff presently consists of a director and a staff assistant with planning underway to complete the central office staffing for MECC by July 1, 1974. MECC central staff will solve educational data processing problems, and provide assistance to the various planning task forces as they work on planning and implementation of MECC activities.

## HOW DID MECC DEVELOP?

The MECC concept and organization was developed by using as a basis all of the extensive planning for educational data processing that had taken place over a two or three year period within each of the educational systems. In each system the planning began with discussion among representative personnel from various levels of the system and proceeded through a research phase to drafting of a final report. These reports were then studied by the Governor's joint committee appointed in 1972 to determine if a cooperative effort was possible. This committee was representative of all the State educational systems, the Governor's office, and the Department of Administration. A planning task force was appointed by the joint committee to study the individual reports, research how a cooperative effort might be approached, and to develop a proposal for the joint committee's review. During the summer of 1972, the proposal was reviewed by the joint committee and the joint power agreement signers during the fall of 1972. The planning task force then finalized the report in February 1973 after incorporating several suggestions and modifications from the reviewers. This report, "A Proposed Educational Computing Organization: Its Facilities and Services" was presented to and reviewed by the Minnesota legislature during the 1973 session and received legislative support.

The MECC board and advisory council were formed and began their activities on July 1, 1973.

## MECC CONCEPT AND OBJECTIVES

The MECC concept can best be stated as a goal whereby the educational computing needs of education in Minnesota will be coordinated through MECC and will be addressed and solved by the State's educators. Through MECC when a problem is identified in one educational system, the problem solution may be obtained by using the expertise from the other educational systems within the State. The process of solution within MECC will be tempered by two basic concepts: 1) the computer utility concept; and 2) the equal opportunity concept. Cooperation and solution of educational computing problems is what MECC is really all about.

The basic objectives for the MECC organization are:

- To *coordinate* educational computing in the State of Minnesota,
- To *streamline* the procedures in obtaining this type of service for the educational user; and
- To *maintain* the educational computing plan agreed to by the educational systems when they adopted the MECC proposal.

The MECC staff, board, and advisory council will continue to strive to meet these goals by following three basis guidelines. First, educational users along with the user central offices including the Department of Education, the State College Board, and so on will *determine* the user *needs.* Second, the user and user central office will receive the money appropriation and *determine* the *expenditure* to be made in trying to meet the identified needs. Finally, MECC, the user, and the user system will *determine* the best alternative *solution* in meeting the needs within the dollars available.

MECC becomes involved at the third step to make sure objectives 1, 2, and 3 are being met.

## EDUCATIONAL DATA PROCESSING PLAN AND PROGRESS

*Involvement of educators.* The progress of MECC has been excellent. Begun in June 1973, the MECC board has organized the advisory council which immediately began its review activities. The relationship between the two bodies is a productive one where the advisory council formally reviews all major proposals or requests coming to MECC and makes a recommendation to the MECC board and the MECC Executive Director. Because the review process involves a large number of educators from various levels and systems of education, this type of involvement helps eliminate the feeling of not being a party to the major decision process of MECC. The procedure used by MECC is a "grass roots" approach that allows the educators on the firing line of the educational process to have a say in setting educational computing policies for the State of Minnesota.

Membership on the board and advisory council, including both full-time members and alternates, involves approximately 50 different individuals. Fifteen different task forces or special subcommittees of MECC have involved 121 Minnesota citizens from all levels of public and private education in the state. The involvement of a large number of people from a wide range of education fulfills one of the basic goals of MECC and partially accounts for the positive acceptance of MECC by Minnesota educators. MECC will continue to promote this type of involvement and support of all educational systems in the state.

*Statewide Educational Computing Plan.* The basis for MECC planning in 1974 centers around the statewide computer plan to which all educational systems in the State agreed when they adopted the original proposal. This plan can be summarized into five separate areas: a statewide timesharing system; an instructional batch timesharing capability; the higher educational administrative data processing system; the elementary, secondary, and vocational administrative system; and the statewide communications network. A short summary of the original plan for each of these areas is listed below[1].

- *Instructional Timesharing:* The plan includes one statewide timesharing system to handle requests from all levels of education. These requests would be for 10-30 character low speed-type activites. This recommendation *did not assume* one computer for the system but did assume a detailed study would be made on how we can best meet the needs in this area. Alternatives include one large central computer, one central computer with satellite computers, several smaller computers, etc.
- *Instructional Batch (RJE):* The batch timesharing requirements for instructional data processing are to be handled by connecting into the Mankato State Univac 1106, the vocational school computers which have that capability (presently Mankato and Alexandria), the University of Minnesota CDC 6600, and the State ISD IBM 370/158's.
- *Higher Education Administrative Data Processing:* The plan calls for most higher education administrative data processing to be handled by the St. Cloud Univac 1106 system, the University of Minnesota IBM 370/145 system, and the Community College IBM 360/25 system. It is suggested that the latter two systems could become one site as the needs and procedures become better identified by each educational agency.
- *ESV Administrative Data Processing:* The planning task force saw this area as the most difficult area to coordinate. The reasons for this are size, geographical locations, differing levels of understanding, differing levels of needs for data processing, historical independence of each school district in going its own way, etc. The plan visualized six ESV centers in the State, one in each corner of the State and two in the metropolitan area. These centers would develop in a specific location after the location is justified on the basis of geography, communications connections, available expertise, interest of the schools in organizing, etc. The eventual development of these centers may or may not confirm that this plan is the most feasible. The organizational development and needs assessments will help finalize this plan or a modification.
- *Statewide Communications Network:* The educational computer plan is *only as good* as the supporting communications network base. This includes a planning process incorporating both utilization as well as cost savings. We envision the complete network to allow any user in the State to travel the communications network to the computer system having the software needed by the user at that time. This plan takes the existing parallel State College, Community College, University, Vocational School, State System, and other systems, and merges them into a common communication system.

The above summary is a base from which education in Minnesota can continue its planning as additional information becomes available and needs are addressed by the various systems within the State. One of the exciting parts of the MECC organization in relation to planning is that it is flexible enough to accommodate changes as they are required by the changing needs of the educational systems.

*MECC Budget.* The MECC 1973-75 biennial budget appropriation is summarized in Figure 1 which includes all appropriations to educational systems within the State for expenditures through MECC. Other monies appropriated to the higher educational systems for educational computing expenditure are also reviewed and coordinated through MECC.

MECC will set reasonable charges for its computer timesharing services, as required by the rider in Figure 1, for on-line computer time as well as for communications charges and central computer site operations overhead. Since the timesharing computer system and physical site have not been determined, charges have not been set at this time. Decisions on these points will be made in March 1975 after bids from computer vendors for the timesharing computer system have been received and evaluated.

## GENERAL PROGRESS OF MECC

The progress of MECC has been rapid over the last few months even though a MECC central staff has not completely been employed. Personnel from the various educational systems working on task forces, advisory committees, the board of directors, and in communicating with each other have been cooperative and are continuing to develop an excellent relationship. As educators throughout the State become aware of what MECC is attempting to do for education, the potential of MECC seems to be exciting members of all systems. Teachers and school administrators are also beginning to recognize the great potential of computer technology in the educational environment. Personnel outside of the educational computing field are also developing an interest in the application of computing for data processing and school counselling.

*Special Task Forces.* Data processing is normally thought of as a machine (computer) and an individual writing programs to make the machine handle data in a particular way. Library data processing is somewhat different from this general concept in that on-line processing and storing of huge amounts of data is required. In most cases, the data must be on-line, or available to the computer whenever information is required from the huge data bank. Since these requirements are somewhat unusual from computer storage and file concept standpoints, library planning needs to be incorporated into the educational computing plan as it is developed for the state educational systems, and a task force on library data processing has been formed to provide direction for MECC.

Figure 1. Proposed 1973-75 Biennial Budget for MECC
(Adjusted on Basis of Governor's Recommendations)

| SERVICE | E/S/V 73-74 | E/S/V 74-75 | JUNIOR COLLEGES 73-74 | JUNIOR COLLEGES 74-75 | STATE COLLEGES 73-74 | STATE COLLEGES 74-75 | UNIVERSITY 73-74 | UNIVERSITY 74-75 | TOTAL 73-74 | TOTAL 74-75 |
|---|---|---|---|---|---|---|---|---|---|---|
| Instructional T/S | | | | | | | | | | |
| Systems Hardware | | 450,000 | | | | | | | | |
| Operations Staff | | 33,000 | | | | | | | | |
| Services Staff | 100,000 | 300,000 | | | | | | | | |
| R & D Staff | 33,000 | 81,000 | | | | | | | | |
| Sub-Total | 133,000 | 864,000 | 70,500 | 100,000 | 90,000 | 150,000 | 162,000 | 234,000 | 455,500 | 1,348,000 |
| Mg. Info. Serv. (MIS) | | | | | | | | | | |
| Systems Hardware | | 180,000 | | | | | | | | 180,000 |
| Operations Staff | | 120,000 | | | | | | | | 120,000 |
| R & D Staff | 60,000 | 192,000 | | | | | | | 60,000 | 192,000 |
| Sub-Total | 60,000 | 492,000 | | | | | | | 60,000 | 492,000 |
| New User Fund (B.P. & T/S) | 20,000 | 30,000 | | | | | | | 20,000 | 30,000 |
| Communications | 204,000 | 511,000 | 39,000 | 61,000 | 153,000 | 153,000 | | | 396,000 | 725,000 |
| MECC Admin. Staff | 51,000 | 54,000 | 6,000 | 6,000 | 10,500 | 11,000 | 8,500 | 9,000 | 76,000 | 80,000 |
| TOTAL | 468,000 | 1,951,000 | 115,000 | 167,000 | 253,500 | 314,000 | 170,500 | 243,000 | 1,007,500 | 2,675,000 |

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*Rider to this appropriation states: "$1,951,000 shall not be available in fiscal year 1974-75 until the Senate Committee on Finance and the House Committee on Appropriations has reviewed the progress of the Minnesota Education Computer Consortium. Recommendations will be made to the Legislative Advisory Committee before March 1, 1974 for the release of the appropriations for the first six months of fiscal year 1974-75, and before September 1, 1974, for the release of the balance of the appropriation for fiscal year 1974-75. The department shall establish reasonable charges to MECC users for on-line computer time actually used. Such receipts shall be deposited in a non-dedicated receipt account of the General Fund."

The charge directed to this task force was to explore the area of library data processing to determine what library problems exist and need to be included in a statewide educational computing plan, and to place priorities on these problems.

*Statewide Contracts.* Statewide contracts for items used by a large number of MECC users, will be helpful and cost beneficial to Minnesota education. The economies of such contracts are obvious when we consider the cost benefit of quantity purchase. However, in addition to the cost savings, the benefits of timeliness and the saving of time by business personnel throughout the educational systems are worthwhile items. Presently when a school system needs a terminal for computing, a bid process is required. Thus, the individual system must wait a period of time until the successful vendor is able to produce and deliver the machine. Once MECC has completed a general contract on terminals, the paper work for individual systems should be reduced tremendously as well as the time required for delivery of the terminal.

*Educatonal System Relationships.* During the past six months MECC has provided a common ground for various educational systems in Minnesota to come together and work toward solving common problems. The process of doing this, which has brought the personnel within systems closer together as well as bringing together personnel between educational systems, has resulted in the development of a much better understanding of each other's problems and objectives. Continuing association should be beneficial not only to the educational computing agencies with the State but should also be beneficial to all areas and levels of education.

*Future Developments.* The future of MECC looks promising. Much of the future will lie in the area of computer-assisted instruction and computer-managed instruction. The computer hardware and software systems being developed today will be the basis for delivering new teaching and educational techniques to all levels of education in the State of Minnesota. The concept of using a master teacher to present materials to students and using other teachers to help the students in a tutorial mode is a real possibility once this delivery system is installed and fully functional.

Instructional use of the computer certainly has exciting possibilities through MECC. Also, showing great potential is the administrative data processing activity within MECC. The MECC educational computing plan for the State of Minnesota will have, once it is complete, a sophisticated administrative data processing capability. Providing the ESV educational data needed by the legislature and other agencies of the government to establish and administer educational policies is a goal that MECC hopes to achieve through the administrative data processing centers. School administrators and legislative representatives will no longer have to wait for reports which are out-of-date by the time they receive them. Information will be on-line to these computer centers and can be delivered by terminal access or by sending reels of tape to the State Department of Education where they will be summarized into the variety of reports required from that agency. This capability will permit the legislature and school administrators to make decisions on factual and up-to-date information rather than attempting to project from data already a year or two old.

## SUMMARY

The MECC organization is approximately seven months old at the time of this writing in April 1974. Views from all levels of education have been pulled together to obtain general consensus and approval for several major advancements such as: the statewide timesharing system; the ESV administrative region plan; merging of administrative data processing on jointly used computer systems; pulling together of school administrators to think cooperatively toward meeting their administrative data processing needs; and thinking and rethinking of how educational systems should be working together to provide the best possible education for their students at the best dollar cost.

MECC success to date begins to demonstrate that implementation of the MECC concept is proceeding in a correct way and that, from an economic standpoint, MECC is worthwhile. Savings will be made not only in hardware and communications dollars, but also in the costs for computer programs and software packages which will be developed once and used by all. Mainly overall improvements in education will result. This improvement is very important since the MECC effort is based on improvement of education and of the educational process.

The MECC Director and the MECC board of directors are convinced that MECC is making real progress toward its objectives, and share great confidence that this progress will continue as representatives from various educational systems continue to work together. Continued conscious effort of these educators, the state administrators, and the legislature will be needed to develop MECC into the successful organization it now has the potential to become. This success will be beneficial to all citizens of the State.

# Coordinating Autonomy: A Paradox?

**by David S. Macey**

This paper discusses the concept of a coordinating agency serving the computing interests of two or more institutions of higher education. The institutions need not be affiliated, although the issues addressed probably vary depending upon the degree to which the institutions are committed to a common mandate or are 'governed' by a common structure. Throughout the paper, coordination is defined as a structure that sustains a rational approach to choice.

Since this paper is written in the context of the work of the Office of Computer Coordination of the Council of Ontario Universities, the issues raised reflect the Ontario situation.

## BACKGROUND

The period from 1960 to 1966 saw the introduction and growth of computing in most jurisdictions of higher education in North America, including Ontario. For the most part, computing was regarded as a new technology. Because its impact as a research tool, an instructional tool, a subject of study, an administrative tool and a planning tool was not clear, the impact on university budgets could not be predicted. The situation was further complicated in Ontario because during the 1960's the government was introducing a complete community college system, composed of 19 new institutions, and developing 8 new public universities in addition to the 6 already present. Thus, the significant rise in computing centre budgets was shielded by the dramatic rise in education budgets in general.

In 1967, concern rose over the spiralling costs of this technology and the difficulty in interpreting the benefit derived. The Committee of Presidents of Universities of Ontario (forerunner of the Council of Ontario Universities) established a Committee on Computer Services, primarily comprised of the directors of various institutional computing centres. This committee proposed the development of computing centres serving more than a single institution and supported a joint university/government study of this concept in 1968. The study concluded that the regional centre plan proposed had neither the economies nor the service offering necessary to make it viable in the light of existing capability.

## THE ESTABLISHMENT OF A COORDINATING AGENCY

The idea of regional computing was abandoned on the premise that, instead, the universities would attempt to effect economies in computing through inter-institutional cooperation. To encourage this approach, the Council of Ontario Universities, in 1969, established the Computer Coordination Group with the approval of the Ontario Government. The objectives of the group were:

- to enable the universities to exploit economies of scale which can be derived from their aggregate purchasing power of computing services in such a way as to negate the effects of geography as far as possible;
- to ensure that the universities are kept informed about developments in computing technology;
- to study and advise on future arrangements for cooperation among the universities in the provision of computer services and on methods of financing such arrangements.

To guide the group in its activities, the Board for Computer Coordination was established to make policy decisions regarding cooperative efforts and major recommendations to the Council of Ontario Universities. In 1971, the Computer Coordination Group was renamed the Office of Computer Coordination (OCC).

Total university participation in OCC was ensured by having the existing Committee on Computer Services act in liaison with the Board for Computer Coordination on matters concerning coordination and cooperation in computing services. The Committee would assist the Office of Computer Coordination in the implementation of approved policies and programs and would be responsible to COU while responding to COU's requests for advice and assistance. In 1974 the Committee on Computer

Services voted to change its role to that of an affiliate of COU, and renamed itself the Association for Computer Services Directors (ACSD). As an affiliate rather than a committee of COU, ACSD has the authority to determine its own membership and many of its own activities and responsibilities. It is still, however, responsible to COU for those of its interests and functions which fall within the scope of the activities of the Council. The current structure of OCC is illustrated in Figure 1.

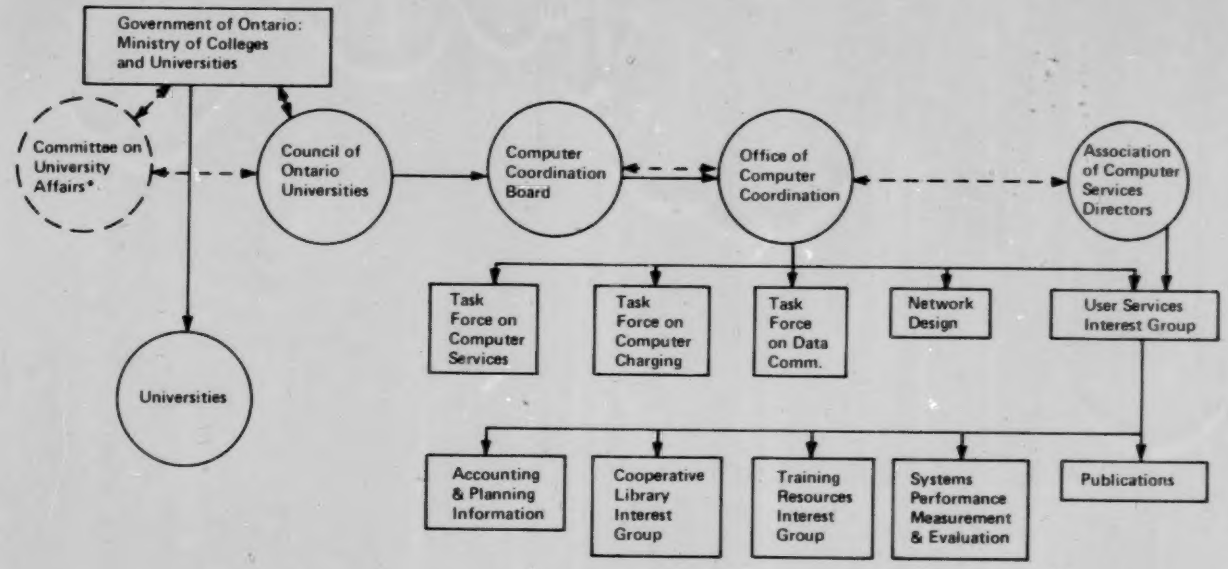
## ACTIVITIES OF OCC

The Office of Computer Coordination, with a staff of two, acting as a catalyst with no administrative or fiscal authority, reviewed its terms of reference and embarked on a number of projects to encourage several forms of sharing that were beneficial to users of computing and responsive to perceived problems and trends:

- adaptation of programming and documentation standards to facilitate the exchange and transportability of software;
- pooling of personnel resources to optimize the development of commonly required applications;
- adaptation of computers with communications capability to facilitate the requirement for special purpose, local computing while providing access to storage capability, to larger processing capability, to general purpose services and applications;
- pooling of computer centre budgets to create fewer but more powerful computer centres to take advantage of economies of scale through load sharing and/or resource sharing;
- formation of user groups, usually of small users, to gain policy and price leverage by using their aggregate purchasing powers to deal with suppliers of computing power and computing services;
- linking together of computer centres with unique hardware, software, services, application or personnel resources by sophisticated communications techniques to enhance the spectrum of services available to a specific user while exercising the economies available through specialization; and
- sharing and exchange of experiences and material relating to user support, hardware, software, planning, and so on, to minimize duplication and maximize return for effort.

OCC activities include the establishment and support of several interuniversity interest groups: shared software libraries, CLING[1]; system performance measurement and analysis, SPMEIG[2]; staff, student and faculty training requirements, TRIG. The office is also concerned with user service and support including accounting and planning information, newsletters, and publication. Task forces have been sponsored to address problems of: data communications requirements[3]; computer costing and

Figure 1. OCC Current Structure



Government of Ontario: Ministry of Colleges and Universities
Committee on University Affairs*
Council of Ontario Universities
Universities
Computer Coordination Board
Office of Computer Coordination
Association of Computer Services Directors
Task Force on Computer Services
Task Force on Computer Charging
Task Force on Data Comm.
Network Design
User Services Interest Group
Accounting & Planning Information
Cooperative Library Interest Group
Training Resources Interest Group
Systems Performance Measurement & Evaluation
Publications

*Changes are currently being implemented in June 1974 with respect to this segment of the Policy/Planning structure.

charging[4]; cooperative planning; the design objectives for networks[5]; network utilization; and the financial, administrative and organizational requirements for system-wide delivery of computing services.

## HAS COORDINATION BEEN A SUCCESS?

COU has received significant international recognition for its work in resource sharing computer network planning and design, and in the field of computer services costing, pricing and charging. The recognition and attention which have served to raise the profile of OCC, particularly in external jurisdictions, have also created internal problems. Of more concern, however, is the possibility that OCC's mode of operation will be perpetuated. In view of its mandate, the success of the office is open to question.

Despite the significant energy, expertise and resources expended on planning and encouraging accountability, cooperation and rationalization in the planning and provision of computing services, the mode of delivery of computing in higher education in Ontario has not changed. Costs continue to rise (15 per cent in the last academic year). With two notable exceptions shared resources are non-existent. System-wide, and in many individual instances, there is little information produced to assist in planning or benefit analysis. Purposeful information, to identify and substantiate opportunities for sharing, is not made available: student, staff, research and administrative data, such as, numbers and types of users, dollars spent, services used; services provided and services desired; utilization of available services; applications and services to be developed; and planned equipment expansions. Though never stated by those responsible for computing, the implication remains that to provide such information is to invite unqualified interference by sinister forces.

System-wide, and in many individual instances, no long range plans exist; nor goals and objectives for computing based on institutional and academic goals or requirements. Simply stated, little is known about why the computers exist or what they contribute to the educational process. This may be explained, in part, by a finding of the British Computer Board, during a visit to North American institutions in the spring of 1973: "Computer management is seen as more of a business activity, not in need of guidance from a senate, somewhat insensitive to the varied wishes of users, and in some instances, markedly authoritarian in giving the university what is good for it". They stated that this does not conflict with their finding that management and service availability are often very good.

The task forces, with their specific mandates, terms of reference and reporting dates, have proven highly successful in studying and recommending solutions for identified problems but equally unsuccessful in effecting implementation of their recommendations. Various interest groups which have produced creditable and purposeful reports, have undertaken numerous activities to encourage adoption of their findings but continually are required to counteract problems of waning interest and decreasing participation. However, the suggestion of disbanding them or OCC inevitably creates a groundswell of support for their continuance, particularly, from those who often seem to question their existence. OCC task force and interest group proposals have invariably met with inconclusive reaction. They have been subjected to continual review and inspection, from seemingly endless numbers of "interested parties" attempting to resolve the most minute points. Their death has usually been the result of institutional asphyxiation.

The two existing examples of inter-institutional shared computing resources have interesting common motivations and solutions. Both were conceived under financial duress, when founders concluded that there were decreased costs and increased potential to be gained through sharing the delivery of computer services.

## PROBLEMS IN COORDINATION

The coordinating agency, although favorable to the institutions in intent and spirit, must realistically view its mandate. Perhaps obvious, but given little regard, the following factors have had a great impact on suggestions for change.

- Universities in Ontario are autonomous
- Early computing environment which necessitated local control together with autonomous institutional policies, effected autonomous computing policies.
- Computers became a prestige factor in institutional image.
- Funding for computing was centralized and the user did not interpret it as a material resource.
- Computer policy and planning groups were comprised primarily of large computing users through an absence of involvement of institutional policy makers.
- Implicit criteria became imbedded in the policy/planning process negating 'make or buy' decisions and analysis of alternative sources of supply.
- Unique machine characteristics and a lack of system, language, documentation and operating system standards made cooperative development difficult.
- Data communications technology was cost prohibitive.
- The career path for the non-academic computer centre director in the university community is limited.
- The decision to fund computing through operating funds and to discontinue capital grants, without equalizing access to the existing

capitalized equipment, created an imbalance in local computing resources which favored the older established universities in Ontario over those emerging under the province's educational expansion program.

In 1968, 1970 and 1974, the universities, concerned about the cost and effectiveness of the delivery of computing services, conducted studies of feasible technical and organizational alternatives. Because the majority of the problems and issues of concern were repeatedly identified in each study, it is reasonable to conclude that the findings and remedies proposed are not totally invalid. Rather the structure for policy, planning and delivery of computer services is resistant to change.

In addition, the following perceived problems, identified in a recent Ontario Government study[6] of its computing activities, hinder bringing attention to problems pertinent to planning, review and assessment. The similarity of these to the preceeding concerns associated with university computing centres appear more than coincidental.

- Some institutions are not assuming sufficient responsibility for the efficient and effective use of computing, in part because of insufficient involvement by top management.
- True costs of computing services are usually not determined, nor are they always allocated to users. Consequently, most users do not know the real costs of using these services, nor do they feel responsible for them. Moreover, there is no incentive for users to demand optimum service at minimum cost. As a result, there is no pressure on the supplier to operate at maximum efficiency.
- Little auditing of computing activities is carried out.
- Long range planning for computing is inadequate.
- Coordination of computing activities is inadequate.
- Users are often uninformed about the capabilities of computing.
- There are no system-wide policies, standards or criteria to assist in computing decision-making.

The autonomous computer centre is not unique to education. The general purpose computer centre has contributed to growth in isolation, perhaps creating an overemphasis on *computers* and an underemphasis on *computing.*

## COMMENTS AND RECOMMENDATIONS

The preceeding section paints a picture of adversity for the role of coordinating. However, contrary to the impression created, cooperation through coordination is a desirable approach, particularly in light of the disruption factor inherent in mandated or imposed programs for sharing.

The Office of Computer Coordination contributed to its lack of effectiveness as a coordinator by embarking on an intense two-year program of research and planning for a resource sharing computer network. Due to budgetary constraints, a conscious decision was made to cut back significantly on external programs in favor of emphasizing internal programs of technical design and development. If coordination is a structure that sustains a rational approach to choice, the agency by definition should be proposing alternatives not solutions. This is not to say that it should be excluded from participation in decision making.

If cooperation through coordination is preferable to sharing through imposition, a realistic assessment of several factors is a prerequisite. Without due regard to these factors in defining a charter for coordination, cooperation will take the form of a paper tiger of good intentions, and the non-technical issues addressed in the preceeding section will continue to erode the benefit to be achieved through coordination.

*Purpose.* The establishment of a coordinating agency implies belief that benefit can be derived through cooperation. The benefit is not without cost, however, the cost being that of replacing independence and interdependence. In Ontario, colleges and universities are, by structure and attitude, independent. Cooperation through coordination requires changes to structure and attitude.

*Policies.* Commitment to a system-wide charter for coordination is only 'patronizing charity' if internal policies are not complementary. Internalization of the charter for cooperation into institutional, departmental and individual policies, terms of reference and job responsibilities must occur.

Neglect of this issue will limit the effect of a mutually defined charter to the level of a compromise with the least expansive institution.

*Priorities.* The sincerity and integrity of adopting and undertaking a mandate to achieve interinstitutional cooperation must be reflected in decision making and planning priorities. Resources dedicated to long range planning in universities have long suffered from the higher priority given resources for day-to-day management. In addition, computer centre management has had to cope with the problems of introducing and supporting an extremely complicated and dynamically changing technology to a greatly varied user community. This has made control of utmost importance to sustain the current level of service, and has limited planning to those decisions intimating the least disruption to the current structure. Because cooperative ventures have the appearance of draining resources from current activities and often are interpreted as external interference, the priority given them is accordingly law.

*Participation and Perspective.* In the absence of policy and without priority, external ventures offer little incentive to individuals and institutions to participate. Perspective is influenced by magnitude. Consider the variance in attitude towards social and fiscal policies between institutions with 1,500 students and seven million dollar budgets and those with 30,000 students and 60 million dollar budgets. The computer centre director in the former may have a seventy thousand dollar budget, while the latter may have four million dollars. Equal resources dedicated to external projects, therefore, range from token to major.

The definition of participation, however, must accommodate issues to be decided by democratic vote and issues to be decided by resource commitment.

Just as a lack of institutional and academic advancement is experienced by the reputed associate professor doing research on instructional technology, it is also not uncommon to the computer centre director, especially if s/he is non-academic. A limited career path is not likely to be conducive to support of sharing resources since it implies lessening of control over local planning, material or personnel resources. In addition, computer centre staff become conditioned to priorities being internal.

The perspective on cooperative ventures would be significantly enhanced if equal recognition and credit were given to the faculty and staff for participation in external and internal activities. By extending internalized and limited career paths into broader interinstitutional projects and agencies, and assimilating the varying levels of perspectives (computer centre, institution, system) into the policies for participation, a coordinating agency could create a positive attitude towards sharing.

*Plans.* Planning processes in universities are cumbersome. The coordinator, in an attempt to promote ventures of system-wide benefit, may introduce proposals contrary to the planning of an individual institution. However, the time, effort and thought expended on future plans by internal committees are not easily modified by what appear to be disruptive, external influences.

Because planning requires analysis, the coordinating agency runs the risk of embarrassing institutions through comparison which may result in resentment, distrust and disdain.

If coordination is desired, a new dimension in the planning process is required. Involved institutions must be prepared to make available, for interdependent planning, information pertinent to the system and to provide for a fair hearing of the alternatives proposed.

*Personalities.* The suggestion of change is a sensitive matter; to plan and propose such creates the possibility of contention. Because the coordinator must interact with the attitude, egos, goals and interests of a pyramid of individuals ranging from presidents to programmers, s/he must be a diplomatic and perseverant individual. However, the cooperative approach to shared ventures is dependent upon retaining majority support for the program proposed. The vested interests in computing at a particular institution are in a much stronger position to influence the local community, regardless of the rationale, than the rarely seen external coordinator. To the degree that the preceeding issues are acted upon, the influence of the personality of the coordinator will diminish.

Cooperation requires trust which cannot be achieved without frank and truthful exchange of information and ideas. Because the coordinating agency is the catalyst for the exchange, adoption of its charter is an expression of commitment. Sincerity requires thorough analysis of the implications of the commitment; integrity requires a decision for involvement based on those implications. Success of the coordinating agency is a reflection of the integrity and sincerity of participating institutions.

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# Chapter 3

## Functioning Systems

### Yes: We Will Share

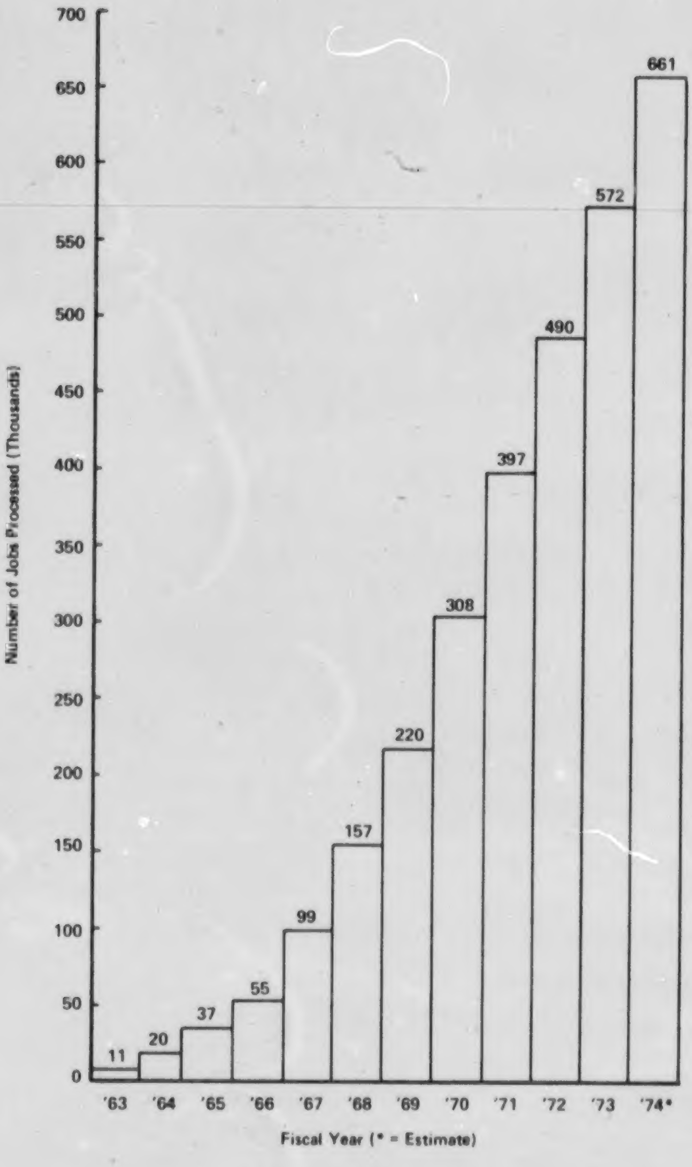
**by E. Rex Krueger**

There is a change taking place in institutional computing, not the change in growth of usage in academic programs as shown in Figure 1, but change in role, function, responsibility, and authority. The same institutions with the same machine, and much the same people, now operate under radically different conditions. The situation is typified by increasing pressures to provide more public service while experiencing tighter and more varied administrative controls.

Academicians have a tendency to think of their roles as in concert with the classical description of a university, an institution to create, disseminate and preserve knowledge. The university, which is heavily dependent on the Cambridge system, has been perpetrated in much the same manner, although more complicated, as grass grown at Cambridge. The algorithm is simple. Spread seed, roll and water once a day for four hundred years.

In many respects present day institutional computing is caught between the forces representing academic heritage, the needs of today's society, and the political factors associated with both. First, institutional computing represents a powerful, modern day, technological tool available to serve the ever evolving, continually growing institutional program needs. Support is provided to instruction with the hope of stabilizing costs while enhancing and enlarging the information flow to the student. As a research

Figure 1. Jobs Processed



tool, computing is used to delve into an ever increasing set of research problems. Many of these have been in existence for years. Many appear in response to emerging critical needs of society. As a utility, the institutional computer is available to serve the public both at the agency level and the citizen level.

Secondly, the institutional computer is a powerful information processor and file manager. It generally has been centralized not only in terms of hardware, but also in terms of management and services. Because of this centralization, the computing center is a facility of which control is recognized as a politically desirable goal. This goal has historically been one which has produced much consternation within the institutions. Remember when the "Godfather of Computing" set up the computer within the Department of ....? Under criticism of providing preferential service to that department, the center was administratively relocated in the college housing that department. Most institutional computing facilities now are supervised by a chief administrative officer. Management control, at least in the case of public institutions, is now an issue at the state and federal government levels. In Chapter 1 Dr. Mosmann identifies an emerging level of bureaucracy for decision making at a level above the public colleges and universities.

Often, the forces at work are indirect. Additional budget review is performed by state agencies because of concern for growing costs (why do students need computer access?). Uniform evaluation and measurement activities are necessary to equalize opportunity in education. Studies on the viability of sharing resources for the sake of the economy are also undertaken by the state. Institutional recognition and desire to serve the needs of the state is another factor. Conversely, non-educational institutions exhibit a crying need for assistance requiring access to effective information processing.

As institutional representatives, many of the "computing decision makers" have willingly been drawn gradually into the public servant role. From the empire builder's perspective, assumption of this role allows construction of a position with increased esteem. From the university's point of view, it allows exploitation of the economy of scale concept, effectively lowering the unit cost to the institution. In the eyes of the university, it is politically advantageous to meet the university's responsibility of public servant. These consequences, based on the perspective of the computing decision maker and the university, are both compatible with the so-called General Motors philosophy, what's good for the nation is good for G.M.

## COMPUTING CENTER AS PUBLIC SERVANT

The University of Colorado Computing Center in its role of public servant, has objectives similar to other university centers:

- Based on planning of all university academic units, provide a level of computer access to all campuses as required for batch and interactive services.
- Encourage research within the computing center and the university to develop and implement new applications beneficial to academic programs.
- Provide, on request, services to state agencies and institutions in support of ongoing programs.
- Provide, on request, services to other non-profit agencies in support of their programs.

Put into practice through the provision of consistently good service in an environment of public need, these goals result in usage patterns described in Figure 2. The fiscal year 1973 data of non-University income on a base of $1,800,000 is even more striking (see Figure 3). For comparison purposes, university support of computing for instruction, research (excluding grant and contract usage) and administration (most done on another facility) was $336,000 in 1973. State usage is heavily weighted by the Colorado Division of Highways. The using agencies in the executive branch are the Departments of: State; Law; Treasury; Personnel; Education; Higher Education; Local Affairs; Natural Resources; Administration; Revenue; Institutions; Military Affairs; Social Services; Agriculture; Health; Regulatory Agencies; Labor and Employment; and Highways.

Of course, there are benefits to all users of the system. An appropriate charging algorithm should result in equal benefits for all users. From the university's point of view, there have been numerous benefits from this mode of operation.

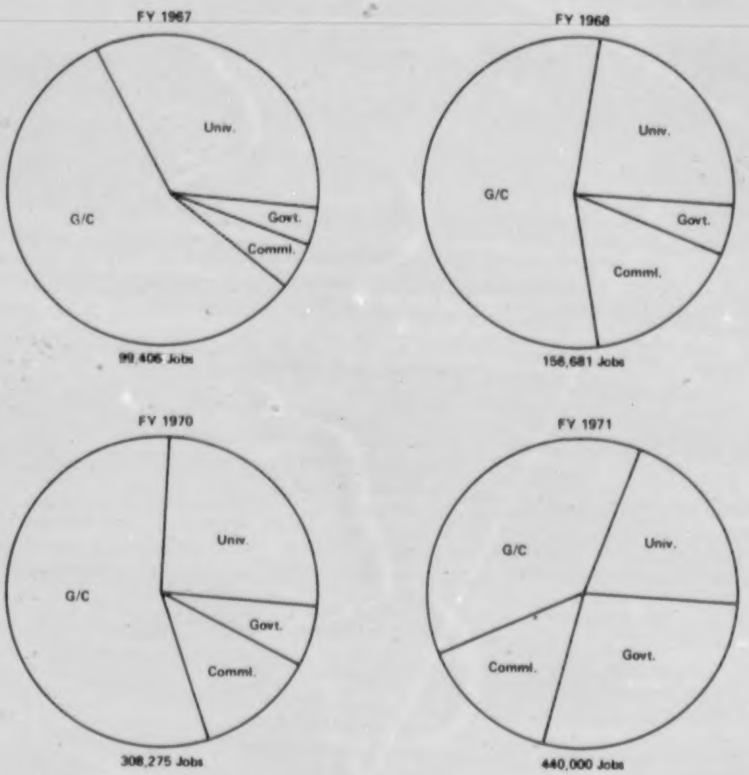
The value of hardware installed at the University of Colorado has grown from about $1.5 million in 1968 to over $6 million in fiscal year 1973. University General Fund investment through fiscal year 1974 in the installed system is about $600,000.

Annual budgets have grown from $640,000 in fiscal year 1968 to over $1,800,000 in fiscal year 1973. Annual General Fund support provided from the university during the same period has grown from $171,000 to $366,039 (all campuses).

Annual processing load has grown from 156,681 jobs in fiscal year 1968 to 571,923 jobs in fiscal year 1973. Approximately three of every four jobs processed are instructional in nature.

Through improvements in hardware and software and a continuing reduction in rate, based on a growing processing load, the unit job costs have steadily decreased. The average student job cost in fiscal year 1968 was $1.85. The average student job cost in fiscal year 1973 was $1.10. Internal university processing rates range from approximately one-third of

Figure 2.



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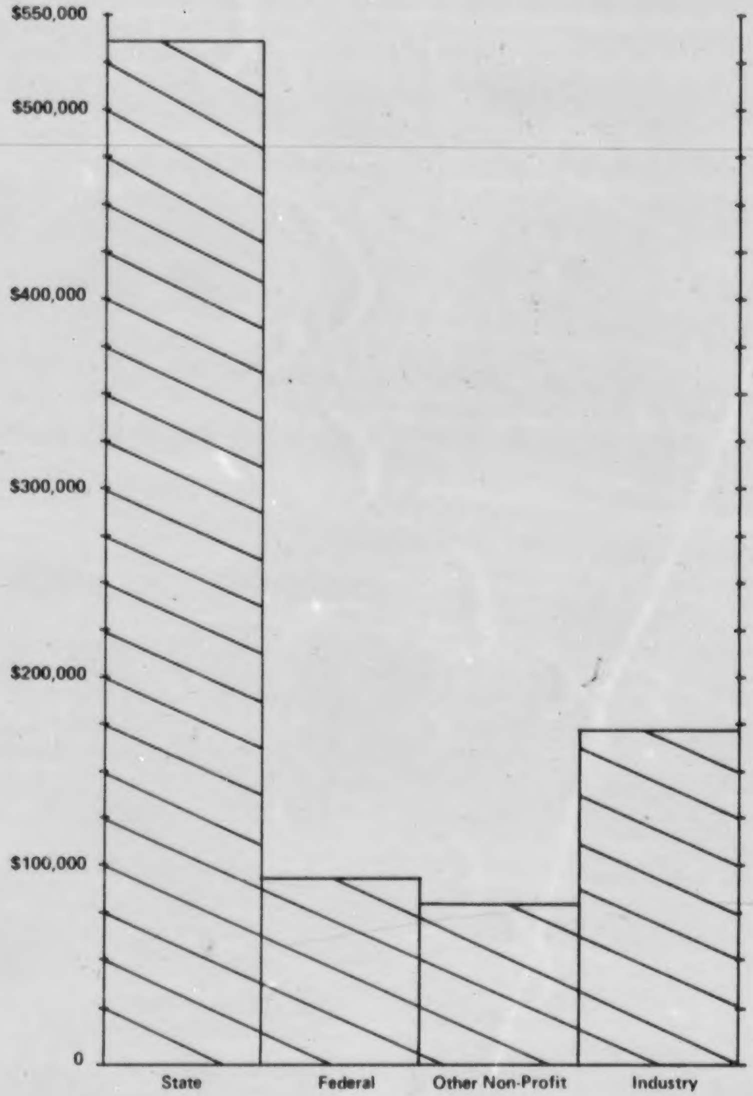
G/C = Grants and Contracts supported work for CU faculty.

Comml = Commercial work.

Figure 3. Non-university Income FY 1972-73



current commercial rates to 65% of current commercial rates depending on resources used.

Economy of scale achieved through the size of the existing computer system allows fast turnaround for the students (on the average, twenty minutes to one hour) thereby allowing the student to operate in a laboratory type environment. Expansion into providing interactive service has allowed continuation of this concept beginning in fiscal year 1972.

Research activities within the computing center were initiated in fiscal year 1968 with a grant from Control Data Corporation. This grant, not associated with a hardware purchase, enabled the development of the center's current interactive computer graphics capability. This capability is now coming into use in the university's academic programs. Additional research grants and contracts have also been awarded. The current level of grants and contracts involving the Center is approximately two million dollars.

Well trained personnel, both in programming and operations, have been attracted to the University Computing Center and are able to pursue careers in a highly motivating professional environment.

In summary, the changes directed toward more relevance, cost benefit, and control are all having an impact on the academic computing center. Computing centers must adjust and re-evaluate. Computing center directors must learn to understand the forces at work in order to correctly play the role of public servant by sharing resources.

## Planning and Management Systems at CCHE

by William B. Adrian, Jr.

Unlike SUNY or the Massachusetts State College System, the Colorado Commission on Higher Education has no centralized computer network to handle its information systems. In fact, the CCHE has only limited access to a computer. As a coordinating commission, the CCHE has responsibility for review of college and university budgets and preparation of budget recommendations to the legislature, review and approval of new facilities requests, review and approval of new programs, comprehensive statewide planning and several additional responsibilities which the legislature has placed on the commission such as coordination of the student aid program, and coordination of the extension offerings in colleges and universities. To execute these functions, the commission has developed several information reporting systems and depended upon the institutions to submit data in required formats. The background, problems, and directions of the planning and management systems effort are summarized below.

### BACKGROUND

The commission has expended a great amount of time and effort in developing information systems over a period of years. The most complex and extensively used system is the budget system, in which institutional budgets are summarized and a series of calculations made for comparative analyses purposes in constructing the CCHE budget recommendations. In addition, there is a facilities system which includes an inventory of all facilities in each institution and a system which summarizes classes and credit hours taught by department and level in all institutions. By combining the facilities and the classes taught systems, it is possible to conduct space utilization studies. There are several other minor systems such as the student aid system, and a system which gathers and summarizes information related to extension offerings.

Recently, the CCHE has focused attention on simulation and modeling systems. Approximately two years ago the Commission initiated a pilot project utilizing simulation and modeling in the form of CAMPUS which was developed by the Systems Research Group in Toronto. It was felt that CAMPUS could replace several existing systems while providing institutions and state agencies an excellent tool for management purposes. There was optimism that CAMPUS could be utilized to build simulation models for institutional and state planning purposes and eventually replace the current budget system. However, the hopes for implementation of the CAMPUS system at all institutions in the state were dashed for several reasons: 1) the lack of understanding of all of the human factors necessary for successful implementation of the system; 2) the great disparity in the status of college operating information systems to feed CAMPUS; 3) the perceived cost and effort to implement CAMPUS on the part of the college personnel; and 4) the general lack of necessary institutional support. Another problem which complicated the picture was the fact that several institutions were already in the process of implementing the Resource Requirements Prediction Model of the National Commission on Higher Education Management Systems. The commission is now encouraging and assisting institutions with the development of both CAMPUS and RRPM systems in the state colleges and universities. The major intent is to provide a forecasting and simulation tool for institutional planning purposes with a secondary intent of utilizing the outputs of the institutional simulations for statewide planning purposes. While institutions may be utilizing different simulation systems, it is expected that significant outputs of the systems will be similar enough to be utilized for statewide planning purposes.

## MAJOR PROBLEMS

A primary emphasis in the CCHE has been on the development of large-scaled and very detailed information systems. As a result there have been great quantities of data available with little staff time to conduct the myriad of analyses that should be conducted. Because data has not been utilized, institutions have become lax in submitting information in a reliable and accurate form. Why should they be concerned if the data are not to be used? This is a major dilemma for statewide agencies.

Even with an attempt to gather detailed information, unanticipated questions continue to arise which call for data gathering and analysis on an ad hoc basis. Thus, there is pressure on statewide agencies to operate continually in a responsive rather than an initiative mode. Institutions and state agencies currently are responding to questions raised by state legislatures which are almost always questions of cost. Leaders of the educational establishment must also be involved in posing the questions to be asked.

The problem of noncomparable data continues to haunt the commission. The CCHE staff has been working on this problem for years and an attempt was made in the early 1960's to identify common data elements for statewide information systems. However, since there is considerable variation in operating systems of institutions such as accounting systems, student information systems, and personnel systems, it is likely that the problem of noncomparable data will be with us for an extended period of time. One of the major efforts of the Commission is currently to concentrate on developing comparable data elements, structures and definitions within one specific area, namely, unit costs by student degree program and level. This information is useful for management purposes at the institutional level and for analysis purposes at the state and national levels. To be properly understood, however, it must be accompanied by descriptive institutional information. At the present time the CCHE staff has accepted the NCHEMS Information Exchange Procedures (IEP) project guidelines as a useful and effective framework in which to gether and analyze unit costs.

## DIRECTIONS OF THE PLANNING AND MANAGEMENT SYSTEMS EFFORT

*Principles.* Becuase of the problems identified, the CCHE is now attempting to raise questions which must be asked of postsecondary education and identify key factors and analyses necessary to assist in answering the questions. CCHE is also attempting to gather on a regular basis only information which will be used, and to explain to institutions how the information will be used by the commission. As a continued effort is made to develop common data elements and common formats for information reporting, the commission is attempting to build on current operating systems within institutions in gathering information for statewide reporting purposes. Because of a lack of understanding and familiarity with current management systems, simulation and modeling capability, and other forecasting techniques on the part of many administrators and faculty in colleges and universities in the state, a major effort is underway to train individuals and planning groups in the operation and use of techniques and information available to them through the CAMPUS and RRPM simulation systems and the Information Exchange Procedures effort of NCHEMS.

*Information Exchange Procedures (IEP).* It is anticipated that virtually all state institutions will be gathering, using and reporting information produced from a modified version of the NCHEMS Information Exchange Procedures effort. IEP appears to be a convenient and useful way to gather comparable unit cost data for institutions and state and national agencies. Recognizing that unit cost information provides only a basis for further analysis, the IEP guidelines also specify gathering information of relevance to specific institutions in order to explain potential variation in costs among and between programs. The target date for implementation of IEP in Colorado institutions of higher education is mid-1975. It is expected that IEP will replace some of the existing data requests which the commission makes of postsecondary institutions in the state.

*Institutional Planning Support.* In another major effort the commission assists institutions to implement and utilize forecasting and simulation tools such as CAMPUS and or RRPM in the institutional planning process. Institutions and the commission staff will be working together to identify the necessary steps, processes and components for institutional planning with the expectation that colleges and universities in the state will have the capability of utilizing these tools in the development of multi-year institutional plans by mid-1976.

*Statewide Planning Effort.* To bring attention and visibility to policy questions which affect postsecondary education, a major statewide planning effort has been initiated. This planning effort will result in policy recommendations in such areas as: access to postsecondary educational opportunity; delivery of educational services; pricing of educational opportunities; the relationship of manpower and educational policy; innovation and flexibility in institutions; the role of graduate education and research; the private sector; governance and process; finance; and perhaps most important, the missions of colleges and universities in the state. When issues such as these are highly visible, information requests will follow from the issues, and the "cart and horse" will be in the proper relationship. Only by relating planning and management systems to basic policy issues can statewide agencies like the CCHE exert leadership prerogatives and have a positive impact on the future of postsecondary education.

## Statewide Administrative Systems

### by James Gaffney

The State University of New York celebrated its 25th Anniversary in 1973. Although people often think of a university as a compact collection of people and buildings at one particular location, SUNY is actually a network of 72 separate public colleges, university centers and medical centers located throughout New York State. SUNY began as a cluster of several colleges for teachers, a few agricultural and technical institutes, and some institutes of applied arts and science. From this, in 1948, the State University of New York was gradually formed which was geographically available to every section of the state and educationally comprehensive from a one-year certificate program to a high-powered doctoral program. During the 1960's the state university reshaped the teacher colleges into strong liberal arts institutions, developed four major university centers, modernized and expanded three medical schools, set up one completely new health science center, and helped build a system of 38 locally-sponsored community colleges (see Figure 1).

Structurally, all 72 campuses function under the overall authority and responsibility of the 15 member Board of Trustees appointed by the Governor. The operation of the university is directed by the Chancellor and his immediate staff known as the central administration. The Chancellor and his staff develop university-wide academic, fiscal personnel and facilities policy, communicate and obtain support for those policies.

**Figure 1.**

10 fully developed colleges of arts & sciences 5 – 10,000 students offers graduate programs up to master's degree
3 new senior colleges being built
1 Empire State – a college without a campus

Special Schools
e.g., agriculture, ceramics, environmental science, forestry, human ecology, industrial & labor relations, maritime, optometry and veterinary science.

Two-year Colleges – Agricultural and Technical College – 2,000 to 3,000 students, a great deal of transfer from these to other units of SUNY.

38 Community Colleges – located in populated areas they are basically commuter colleges. Enrollment is approximately 375,000 students.

Teachers number approximately – 14,000

Operation Budget is roughly $800 million/year.

The central administration is segmented along functional lines and offices e.g., Academic Affairs, Facilities Planning, Finance and Budget, and Office of Computer Systems Development which has responsibility for a number of functions that are all computer oriented. From the administrative viewpoint alone the reporting problems with which the Office of Computer Systems Development must deal to handle over 300,000 students control an $800 million budget are enormous.

It was realized many years ago that some form of uniform data gathering and reporting was absolutely essential if a business-like approach was to be taken in the management of the University.

## THE DECISION TO DESIGN AN MIS

SUNY, like many other institutions, explored a variety of methods to make data reporting both on and off campus uniform. However most plans were tried by several campuses in a regional area on a pilot project basis. Problems arose, however, because one group or another, the "ins" or the "outs" felt cheated by such a project.

SUNY Central Administration then explored the known possibilities at the time and for various reasons arrived at one final method of processing. The alternates studied to arrive at this decision included:

- process regionally at one of the four university centers;
- process sub-regionally at 8 or 10 area centers;
- process centrally at one large center; or
- process on-site at each campus.

The decision made in 1969 to process on-site with a uniform system is being reviewed annually.

During the review process systems were evaluated on the ability to handle academic data processing along with administrative data processing.

Because central or regional processing is less expensive, but lacked the vital ingredient of wholesale participation, the Office of Computer Development staff compromised and decided to perform administrative processing on each campus on a free standing system, and to perform the bulk of academic processing off campus at a regional or central site.

In 1969, all of the four year colleges of arts and sciences reached a growth period where, almost simultaneously, they needed an increase in computing power. This demand was the catalyst to begin in earnest a program of developing uniform administrative systems.

The four year college plan included four phases: 1) Definition of computer hardware needs with a five year projected growth; 2) Through extensive bidding selection of a common computer system; 3) Creation of design mechanism for uniform administrative systems; and 4) Organization of a university-wide programming and implementation staff.

At the time the first phase began, SUNY had a conglomeration of hardware devices in the four year colleges. One had as little computing power as an IBM 403 while others had 1130s, 1401s, 9300s and 360/20s and 360/25s. Although there was some variance regarding student population, the colleges all had essentially the same processing needs. They needed a number of systems and a certain size data base to support those systems. The decision was made that these systems would be almost exclusively used for administrative purposes, and, if any academic processing were to be performed on them, it will be done with whatever excess time and facility was available. All campus computer center directors participated in the definition of their present and projected needs along with the staff of the Office of Computer Systems Development.

In the second phase bids were let and a common computer system selected using standard New York State procedures. The same Office of Computer Systems Development personnel plus a representative of the Division of the Budget worked on the project. With standard hardware selected, the office could proceed with the building of a uniform system for processing.

In phase three OCSD staff again were faced with options:

- Hire a consulting firm, experienced in the field of educational data processing and obtain a system at various stages of completion;

- Lift the best system in each area from one of our campuses and accept it as the standard; or
- Build each system from the ground up.

The first option was by far the quickest and probably the easiest, but it required the largest direct expenditure of money. Desirable as it was, it was rejected for that reason. The second alternative was rejected because it was soon obvious that even the best system available needed extensive modification for university-wide use. However, portions of existing systems could be used in a generalized system. The major drawback of the third option was the extensive time required to build each system from the ground up. Although the resulting system would be completely customized to the university needs, OCSD staff questioned whether anyone would be around to see it completed. The decision was made to use a combination of options 2 and 3.

Task forces were established for each system area: Student Records; Personnel; Facilities; and Finance. Coordinating the entire activity was an MIS Task Force made up of original task force members. The responsibility of the MIS group was to ensure compatability of design and standardization of coding.

Each Task Force, after a number of false starts, was comprised of an equal distribution of user and data processing people along with a representative of the Office of Computer Systems Development. Because earlier efforts to design an MIS within the university floundered with data processing people solely in charge of system design, in the new effort OCSD made certain the user was an active participant in the entire design process, not merely at the beginning to lay out the requirements, but throughout the work of the group to ensure that all the needs were addressed.

Although the task forces were limited to representatives of only a few campuses (5-7) to allow workability of the group, they were required to set up a communication line to a number of offices on each campus. The intent of this requirement was to obtain concurrence from all the users, not only representatives, as the system was being designed. Using this structure, by the time a system was completed, it had been reviewed at a number of different steps along the way and would need no more approvals. This has been the case, and although the design time exceeded estimations due to the continuing approval process, the final product has been received enthusiastically.

## TASK FORCE WORK

The Student Record Task Force began work, as did the others, by contacting each campus within the SUNY system, to request a presentation of that campus system if it was felt that such a system could form a base for a SUNY standard system. After a number of campuses made presentations one was identified, from a university center, that, with modification could be built upon for a university-wide Student Record System. As it turns out, the modifications were so extensive that the Student Record System is unrecognizable today in its original form, and the original campus has installed the new system replacing the old.

Because SUNY with individual college campuses is no different from any coordinating agency, the central administration cannot dictate, and each individual has unique methods of doing things. Systems enforcement can be done only where the campus reports data to the central administration or fulfills federal requirements. However as SUNY reporting needs grow and continually fluctuate, the central administration requires quick information from the campuses. These requests are the primary factor moving the campuses to a more standardized system.

Because the Office of Computer Systems Development could not dictate to the entire system, the goal of task force work was to standardize on the smallest segment of the information system which would have the least affect on the individuality of the campus. OCSD therefore set about to standardize data elements and publish a dictionary of elements that satisfied central reporting and which followed federal, WICHE and state requirements. A given campus need not store all the data in the dictionary. However, first aligning existing definition with the standard data element was no small job since all the various definitions that had been used on our campuses for years had to be condensed to a single university-wide standard. Development time for the Student Record System was approximately one year.

The Personnel System was designed completely from the ground up. Data element definition was the first task, with all of the related approvals, and systems design, programming and implementation on campuses followed. From the beginning to its final acceptance by users, this system was worked on for about two years. The Facilities System has turned out to be very heavily oriented to the Central Office with very little processing performed at the campus level. A number of remaining segments to each of the main systems are continuing to be designed or in some cases modified based on needs in the field. The Financial System, which is the last remaining major area, is currently being addressed by task forces.

## ELEMENTS OF THE SUNY SYSTEM

In the SUNY standard administrative information system there is an obvious absence of reporting programs. Because the primary intent is to supply a uniform system, reports are not provided with all their inherent subjective tailoring, but rather a data base editing and maintenance system is offered which campuses can access as they see fit. A Tailored Report

Generator Program includes a catalog of reports which is being increased continually, and which can be called by including only a single parameter card to the TRG deck. One quite complicated report, which is required by the State from all the campuses, is the Course and Section Analysis (CASA) which is a statistical study by course of: instructor; numbers of students; classrooms; facilities; and hours; and so on. Results show space utilization by course, teaching load by major department, and similar analyses.

Other than the TRG and CASA reports no reporting restrictions or requirements are imposed on the campuses. No grade reporting, transcripts, internal admissions reports, probation reports or others are included in this MIS package. To an outsider, each campus appears to have an independent custom MIS.

## UNIVERSITY SYSTEMS SUPPORT GROUP

In order to carry out the programming required to computerize the designed systems, a university-wide programming and implementation staff of five people called the University Systems Support Group was established. To avoid restricting the system to being computerized while also insuring a relative ease of programming, this group meets with the design task force before the design work has been completed, but not at the very beginning of the effort. Once the design work is completed, the project is turned over to the System Support Group for programming, the design task force continues to oversee all work to guarantee adherence to specifications. When the programmed system is ready for implementation, representatives of the System Support Group conduct seminars and go to each campus to aid local staff in the installation of all parts of the system on each campus.

On-going activities of the group include revision and maintenance of existing systems as well as new design work.

The SUNY Office of Computer Systems Development has, by 1974, produced and implemented the following systems elements:

- Standard coding;
- Standard data definition for statewide reporting;
- Customized data definition for statewide reporting;
- File editing and maintenance routines;
- Data relationship definition and checking routines;
- Report generator;
- Statewide reporting of required standard data; and a
- Table for customizing output reports.

# State College Computer Net

**by Leo Roomets**

The Massachusetts State College Computer Network was established in October of 1973 to provide a computing and data processing resource for the eleven state colleges of Massachusetts. The network consists of a Control Data Cyber 72 computer located in Boston which supports both remote batch and interactive terminals located on each campus tied in via a state Telpak network. Patterned after the classic star configuration, the centralized network currently bridges the developmental gap between what was once a cluster of small independent computer operations and what will eventually be a hierarchical computing network.

The distinguishing feature of the network, however, is the variety of functions which it is designed to support and the services which it offers. Breaking traditional academic-administrative detente, the system provides a single resource for all instructional, administrative, research and public service computing requirements of the colleges. Additionally, the network center supports a systems and programming staff charged with the responsibility of developing and implementing an integrated information system designed around linked data base structures and intended for use in an on-line, real-time transaction-oriented environment.

In order to maintain fairly a multi-institutional user-oriented service, the center has been established as an organizational entity separate from the colleges, and its management reports to the Board of Trustees of the State College System through the provost of the system.

## HISTORY OF THE SYSTEM

Computing is a relatively new addition to a system which has a history that dates back to 1839. Although this factor has been the source of innumerable headaches and general technology shock, it has also been the single most significant factor which has allowed the colleges to leap-frog two decades of technological growth and development in both hardware and software concepts in less than three years.

In 1965, the state colleges acquired unit record and tabulating equipment to support the processing of student and financial data. As some of the colleges grew in size and concomitant data processing requirements, small computers were leased by half of the colleges. Although usage was still primarily administrative, a few colleges acquired minicomputers to be used in teaching physics, chemistry, and mathematics. The year 1965 also marked the year when the state colleges were organized under a single Board of Trustees with governing responsibility. This change presented individual colleges with the added task of responding to many new requests for information concerning all the activities of the institutions, requests which the traditional information collection and processing procedures were not designed to handle effectively.

The late 60's also marked a period of change in the public attitude toward traditional unquestioned state support of public higher education. The Board of Trustees of the State College System felt the pressure for accountability, for curricular relevance, for effective resource management, and for justifiable expenditures of public money. In responding to increasing criticism and closer scrutiny of the capital and operating budgets of the colleges, trustees and presidents alike realized the need for more meaningful and accurate information to defend their requests and their programs.

Furthermore, computers in general were penetrating into all facets and levels of business, education, government, and industry. As a result, both faculty and students were putting pressure on the colleges from within for more sophisticated and more accessible computing capability; employers as well as graduate schools were looking for students with computer skills.

It was in the context of this environment that the use of computers to support academic and administrative requirements began getting special attention in 1971. An individual was hired by the Office of the Board of Trustees of State Colleges to analyze and document the management information systems and the instructional support systems required by the State College System, and to recommend a plan of action which would result in the development of an effective and economical computing resource. This feasibility study indicated to the trustees that: 1) the management information needed by trustees, presidents and college administrators could be supplied only by information systems and procedures which were considerably more advanced and sophisticated than those which were currently in use; 2) the faculty and students could benefit significantly through the expanded use of the computer in a variety of disciplines; and 3) the proliferation of independent computing solutions (service bureaus, local hardware, consortia) could not provide an effective, cost-justifiable capability to meet short-term or long-term needs. The major recommendation of the feasibility study was to develop a computing master plan which would contain detailed information system designs, guidelines for the development of instructional computing, an implementation plan and timetable, hardware and software specifications, and personnel and budget requirements for the next five years. Because the final plan had to be acceptable to all members of the college community before it would be approved, the planning process had to incorporate major user educational approaches in addition to considerable user input and evaluation.

The details of the project were worked out, and in May, 1972, systems staff began the analysis and design work assisted by Systems Research Group, Inc. After eight months of interviews, meetings with college and system-wide committees, and presentations to administrators, presidents, and trustees, the plan was completed. The trustees voted approval of the Master Plan for Academic and Administrative Systems in February 1973. The Plan, documented in five volumes and over 2,000 pages, was perhaps the most comprehensive set of designs and specifications ever developed for a group of colleges. Incorporating the experiences of other systems of higher education like the California State Colleges and Universities, the State University of New York, New Jersey Educational Information Services, Inc. and others, the Massachusetts plan included state-of-the-art concepts in systems design, teleprocessing, and network organization, in addition to management system concepts developed by WICHE/NCHEMS.

*Volume I, Summary and Recommendations,* consists of a summary of the project recommendations to the Board of Trustees and a plan for implementation.

*Volume II, Analysis of Current Operations,* consists of a detailed analysis of the academic and administrative data processing activities at each of the colleges.

*Volume III, Academic Computing,* consists of a discussion of the current and future use of the computer in instruction, research and public service. It also includes specifications for a Curriculum Evaluation System and a Research Management System.

*Volume IV, Administrative System Specifications,* consists of detailed specifications for the State College information system. General description, flowcharts, process descriptions, definitions of inputs, files and outputs are provided for the following subsystems:

- *Planning and Budgeting*
  Program Planning
  Multi-Year Budget Planning
  Simulation Modelling
  Facilities Planning
- *Statistic Reporting Systems*
  Curriculum
  Finance
  Personnel
  Physical Facilities
  Students
- *Student Systems*
  Administration
  Financial Aid
  Residence
  Registration
  Grade Reporting/Transcripts
  Counselling
  Alumni Reports
  Attrition Analysis
  Student Records
- *Financial Systems*
  Accounting
  Budgetary Control
  General Ledger
  Payroll
  Purchasing/Inventory Control
  Accounts Payable
  Accounts Receivable/Student Billing
  Cost Analysis
- *Personnel Systems*
  Personnel Records
  Assignments
  Activity Analysis
  Collective Bargaining/Contract Management
  Personnel Evaluation
- *Physical Facilities*
  Facilities Inventory
  Facilities Utilization
  Facilities Management & Planning
  Maintenance
  Capital Budgeting
  Building Project Control
- *Curriculum Systems*
  Program Analysis

Program Evaluation
Course Catalog Curriculum
Curriculum Planning

- *Institutional Support Systems*

Library acquisition, cataloging, and circulation control

*Volume V, Data Element Dictionary*, consists of a cross-referenced index of all data element codes and names used in the Administrative Systems Specifications.

## NETWORK DEVELOPMENT

Upon acceptance of the Master Plan, the Computer Services Staff began all the activities which were required to implement the plan's recommendations: building of a computer network; hiring and training of personnel; and development of systems to be running by the Fall of 1973.

The central site was prepared and the CDC Cyber 72 installed on October 15, 1973 as scheduled. By November, the eleven state colleges were all accessing the system through the time-sharing and remote batch systems and processing their first jobs over the Massachusetts State College Computer Network. After the first two months, during which the operating system (KRONOS 2.1), the hardware, the telecommunications network, and the personnel went through an initial shakedown period, the network began offering reliable services to the administration, faculty, and students at the colleges. Usage of the network grew from roughly 2500 jobs per week to nearly 20,000 jobs per week by the end of the Spring 1973 semester.

One year has been allowed for the conversion of college data processing from dependence on local hardware or service bureaus to complete reliance on network resources. In early 1974, many of the colleges have already completed the conversion of all software, and have released equipment which is no longer required for network processing. Other colleges are still running dual systems, but expect to be totally on the network by the Fall of 1974. To assist in this process, the network center has developed an administrative software library and clearinghouse for interim systems. Programs written at the Massachusetts state colleges or acquired from external sources such as CAUSE, or other colleges and universities, are available for use by any of the user institutions. Internal consulting services, user training, and programming assistance have also been provided to facilitate the transfer of user institutions to state systems. Internal consulting services, user training, and programming assistance have also been provided to facilitate the user conversion process.

With the continuing support of the Commonwealth of Massachusetts, the board of trustees, and the general college community, the State

College Computer Network staff expects to complete the development and implementation of the systems contained in the master plan by the Summer of 1979. Given the relative success to date, and the enthusiasm of the users of the network, the staff looks forward to the opportunity to make a significant contribution to higher educational computing and management systems between 1974 and 1979 and thereafter.

# PART II

## WAYS IN WHICH COMPUTING CAN BE DELIVERED

# Chapter 4

## Delivery of Computing in Academic Institutions

**by Leland H. Williams**

The first thing I realized about the title of this talk upon receiving it from the organizers was that it has nothing to do with van shipment versus air freight or anything of that sort, and that there were some other implied constraints when the title is taken in context with the conference theme and with EDUCOM's objectives. Furthermore, it was obvious to me that any claim of completeness before such an illustrious audience would be very ill advised. Therefore, I have retitled the talk "*Some* Ways In Which Computing Can Be Delivered *in Academic Institutions.*"

With the topic reduced in size, I then began to consider what I might be able to say that would be of use to this audience. Certainly I know something about *one* way in which computing can be delivered and that, of course, is the way in which computing is delivered to a wide community of users by the Triangle Universities Computation Center. I quickly concluded that the organizers would not want me to further constrain the title to *one* way in which computing can be delivered. Thus I looked back into my own previous experience and realized that I could speak from experience at Auburn University and at Florida State University concerning single university general purpose computing centers. I also looked back to my own learning experience at the console of an IBM 650 and reasoned that I could speak from experience about this kind of delivery of computing service as well. However, I realized that most of you have had similar experiences, and that I would have to do more than this. I then began to look in current literature for surveys of ways in which computing service can be delivered in the academic community. I was not at all surprised to discover a new book by Charles Mosmann, but I was overwhelmed by the singularity of finding Professor Mosmann on the same EDUCOM conference program immediately preceding my presentation. I decided that the only way out was to own up to my debt to his new book immediately. The book is entitled "Academic Computers in Service" which was published by Jossey-Bass in 1973.

The topic, "Delivery of Computing in Academic Institutions" even though proscribed to be "some ways in which computing can be delivered in academic institutions," is multi-dimensional and requires some kind of sectioning in order to view it properly. Following Mosmann's approach, I have chosen four major categories to which a sectioning process will be applied. The categories are:

- Campus Computation Center
- Distributed Computing on Campus
- Commercial Services
- Super Centralization

## CAMPUS COMPUTATION CENTER

There are a variety of reasons for the existence of campus computation centers, but economy of scale is the primary reason in most cases. Grosch's Law continues to hold, making a unit of computation cost less on a large computer than on a small one. One must, however, be careful about the scope of application of this so called law. For the purposes of this paper it is sufficient to claim that the law does continue to apply to general purpose instructional, research and administrative computing on the college level. It may not apply to certain on-line or real time computing such as process control, and there may well be other exceptions.

Another reason for the continued existence of so many campus computation centers is the management control provided thereby for the university administration. It is natural for university administrators to want to be able to turn to one source to learn what computing is costing and what services are being provided to the faculty, students and administrators in return for that cost. Of course, there is a third question that a university administrator would like to ask – "Why can't you provide more computing for less cost?" It is not clear how well one can answer these questions for university administrators, but the ability to direct these questions to one source is one of the major reasons that campus computation centers exist.

Another reason for campus computation centers is college pride. It continues to be desirable to show off the computation center despite a tendency in new construction to hide it for security reasons. The pride reason is not without economic benefits. There are several named general purpose computation centers in our universities. For example, there is the Rich Electronic Computation Center at Georgia Tech and the Abraham Smoots Research Computation Center at Brigham Young University. I assume that in such cases there were financial considerations involved in the choice of the name. As Charles Mosmann observes[1], it is difficult to conceive of the John Q. Alumni telephone bill fund for provision of computing services at some remote location.

Having considered some cohesive forces relative to campus computation centers, let us now turn to some unstabilizing forces. Perhaps the most obvious one is the generally unsettled question as to whether college administrative computing can or should be done on the same machine with research and instructional computing. I say that this question is generally unsettled because there are about as many colleges which have settled the question one way as the other for the time being. The case for separate facilities for administrative computing is generally a statement of special requirements for security, reliability and predictability, but these are requirements for instructional and research computing as well. The argument for separate administrative computing facilities usually also includes a claim of special priority for such important services as payrolls. However, it is debatable whether the payroll is any more important than the preparation of data for a research professor's presentation to his society. The answer to both problems may be the same: proper scheduling and planning to minimize the need for special priority service. Also, it is important to realize that college administrative data processors can be expected to share a general campus computing facility only if they are given solid, firm commitments for computer service (including special priority when required). The technique for implementing such commitments is another subject, which is addressed primarily in the context of commitments within the TUCC partnership for instructional and research computing in a paper on TUCC (Williams, 1972).[2]

The computer science department and other academic departments also claim special needs which may be used to justify separate computing facilities. In cases where these needs require real time or on-line applications, separate facilities may be justified. Operating system interaction and development or support of large interactive memory driven CRT displays may also require separate facilities.

An obvious variation of the single campus computation center is seen in the university with multiple campus computation centers. A good example would be a multiple purpose computation center within the medical school or some other specialized school, plus a general purpose facility serving the rest of the campus. At some institutions the administration seeks to exercise its management jurisdiction over such multiple centers by creating a university computing office which seeks to manage both or all facilities. Such plans meet with varying degrees of success.

Space does not permit exploration of all service aspects of a campus computation center, but one, interactive services, does warrant further discussion. There are two primary ways in which the campus computation center can seek to meet campus needs for interactive computing. First, interactive computing can be provided on the major general purpose computer. Numerous institutions provide some combination of APL, FORTRAN, PL/I, and BASIC, on a major general purpose computer. However interactive computing provided in this way tends to be relatively expensive because of the generality of the major computer's operating system. Therefore, there is a movement beginning in some institutions to provide, in addition to these sophisticated interactive computing services on the major computer, unsophisticated, relatively cheap interactive computing service via a mini-computer under the auspices of the campus computation center. This kind of activity is perhaps best developed currently at the University of Iowa.

## DISTRIBUTED COMPUTING ON CAMPUS

A second major category of computing service delivery is distributed computing. In this case there is no central management of the distributed computing facilities except the university administration itself. Either major or mini computers may be involved and they may be used for either general purpose computing or interactive computing or both. With regard to mini computers, it should be noted that satisfaction with general purpose computing is limited by the state of development of higher level language compilers for these machines. However, for relatively unsophisticated single language interactive computing service such as BASIC, it is difficult to compete with minicomputers.

A major factor in distributed computing is the micro-computer or programmable calculator. At one of the universities in the TUCC network, about ten of these devices have been bought for prices ranging from $1,000 to $6,000, primarily for quick laboratory data reduction. Because these purchases have bypassed the committee responsible for computer and computer terminal acquisition, that committee now has on its agenda the question, "When is the calculator a computer?"

## COMMERCIAL SERVICES

Commercial services represent another method of delivering computing for academic institutions. Such services are available both from computer time vendors, whose primary business is selling computer services, and also from other businesses that have excess time to sell. In either case, but especially in the latter, the educational institution should be careful to insure that it is contractually protected against the unilateral withdrawal of services on which it has become dependent. Another possibility is the purchase of excess computer time from academic institution. The same caveats apply.

## SUPER CENTRALIZATION

Super centralization can reasonably be viewed as a way to extend the advantages of intra-campus centralization to inter-campus centralization. Economy of scale is still available at this level for many institutions. Most of the technological problems of super centralization have already been solved. The remaining problems, which have been solved to some extent in some places but remain challenges in other places, are the political and managerial problems. The super centralization model may be implemented in three ways. The first two provide general purpose academic computing whereas the third provides computing for one narrow discipline.

- Star Regional Networks
- Distributed Regional Networks
- Discipline Oriented Centers

A star regional network maximizes the economy of scale benefits. See Williams 1972[2] for an in-depth description of TUCC, a functioning successful star network.

A distributed regional network maximizes both multiple service availability and inter-campus research cooperation. MERIT, a system which links the computing facilities of the University of Michigan, Michigan State University and Wayne State University, exemplified this model. Major computing facilities and services on any of the three MERIT campuses are available to users on any campus under certain terms. Another example is the ARPA Network which illustrates a non-restrictive use of the term regional, since the ARPA Network now extends from Hawaii to Europe. Another example of a distributed network which also has some attributes of a star network is the present proposal of the Computer Board for Universities and Research Councils of the United Kingdom.

The discipline oriented centers, which can function either by mail and travel or as a star network, maximize the ease of maintenance and availability of large data bases and special programs. The National Center for Atmospheric Research at Boulder is a good example of the mail and travel type of discipline oriented center, serving researchers in the meteorological sciences. The Daresbury (England) Nuclear Physics Laboratory is a good example of a star discipline oriented center[3]. Access to an IBM 370/165 is provided for a community of high energy physics researchers.

## SUMMARY

There is a wide variety of ways to provide academic computing services. The choice criteria have been only briefly explored here, but some pros and cons have been presented for each of several ways of delivering computing on campus.

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3. Zacharov, B., "Integrated Computer and Data Processing Networks" *DNPL/P 155*, Daresbury (England) Nuclear Physics Laboratory, May 1973.

# Chapter 5

## Combined or Separate ADP and Academic Computing

### Introduction

**by Jeremy E. Johnson**

The objective of this chapter is to provide readers with insight to assist in making "fair and rational" decisions about the allocation of computing resources, with particular reference to the method of organization of institution-wide facilities.

Most of the discussion of this topic has been neither fair nor rational, and has been based primarily on protection or expansion of empire. Papers in this chapter have some suggestions on how to minimize impacts on personnel, but concentrate on operational rather than political aspects, which tend to be highly specific to local conditions.

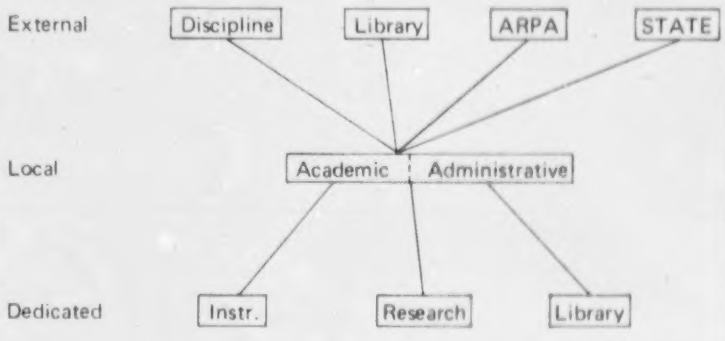
Useful consideration has been impeded by lack of recognition of the importance of economics. Any form of resource sharing is attractive because of the force of funds. If unlimited funds were available, each function would be best served by a completely dedicated facility. The idea of each researcher having his own ARPA net and each administrator an analogous net is clearly extreme, but many discussions fail to be specific about whether they cost the same or more or less than the alternate with which they are compared.

One might, then, take as the object of the "rational decisions" the provision of a given level of services at the lowest possible cost or the provision of the highest level of services for a given cost. Someone who is operating equipment one or two shifts, five days a week and has all the appropriately trained personnel needed to serve users' needs either has no problems or has problems with a different solution than a consideration of combined or separate centers!

The tradition of combined or separated centers has been largely inherited from organizations developed from a mode of operation with lots of "hands on" job responsibility and little remote access. Current experiences should serve as a bridge to help to answer the question of whether combined or separate local centers will be optional in the context of the hierarchy which may be expected in the future. Small machines will be dedicated to particular narrow types of services. Large "local" center(s) will serve a broad set of campus needs, and regional, national, or international centers will supply access to particularly specialized facilities. (See Figure 1.)

The questions about effective relationships between the levels outlined in Figure 1 are interesting and are explored in other chapters. The question from which papers in this chapter begin discussion is whether "local" delivery of computing services can better be done by one center or two.

**Figure 1. Hierarchical computing on campus**



## A Combined Center

**by William E. Walden**

At Washington State University the Systems and Computing organization which is responsible for all computing related functions includes the following groups:

- *Academic Services.* A Group which assists faculty and students in using the Computing Center and provides systems analysis and programming services for academic systems.
- *Administrative Services.* A Group which assists administrative offices in using the Computing Center and provides systems analysis and programming services for administrative systems.
- *Computing Center.* The major computer is an IBM 360/67. With the exception of some special purpose computing, all university computing is done in the Computing Center. Also, 27 other educational institutions purchase computer services via remote terminals.

An IBM 360/67 was installed at Washington State University in December, 1966. Long before this installation a commitment had been made by the university to provide all major computing services, administrative or academic, with the 360/67. Very few individuals need to be told that the 360/67, running under OS/MFT, could not be used very efficiently when it was first installed. At that time with a peak load of less than 14,000 jobs per month and an average monthly load of 11,000 jobs, the turnaround was not particularly good.

Quite frankly, in that environment there were some conflicts between administrative and academic users. There was no satisfactory way to mix jobs or to set priority on jobs. Hence all users had severe turnaround problems from time to time. Although it was not necessarily justified, there was a natural tendency on the part of the academic and administrative users to hold the other group responsible for their difficulties.

The processing of administrative and academic jobs on a single computer in one computing center is done quite smoothly now. No distinction is made between administrative and academic jobs. Jobs can be scheduled a week in advance or submitted on an unscheduled basis. Unscheduled jobs can be submitted at four priority levels with higher cost assigned for higher priority level. During 1973 the Washington State University Computing Center had a peak monthly load of 38,000 jobs and an average monthly load of 27,000 jobs. Many of the other educational institutions which are now using the Washington State University Computing Center submit both academic and administrative jobs. Also, in December, 1973 the computing center was designated as a State Data Processing Service Center. Hence there is a long range commitment to process jobs of all types.

Some of the reasons that things are going more smoothly now as compared with the first year after installation of the 360/67 are:

- Conversion to OS/MVT as an operating system for the 360/67 allowing for improved job mix and automatic priority pricing;
- Systems and operations improvements that have resulted in increased efficiency in the use of the 360/67;
- Priority pricing and user ability to schedule jobs a week in advance;
- More jobs being submitted from, and output being sent to, remote terminals.

A single computing organization, and a single computing center for all of the university is working well. A major problem for university computing centers is peak loading which occurs in the second half of the instructional period, at WSU, the semester. Academic peaks do not necessarily coincide with the administrative peak, so the computer load is leveled to some extent by processing all jobs in one facility. On a large 360 used for general purpose computing, the mix of administrative and academic jobs results in more efficient use of the equipment. For example, many of the high input/output, low CPU, administrative jobs mix well with many of the low input/output, high CPU, academic jobs. So far one large computer, rather than two small ones, has met the tremendous variety of requirements that university users have in terms of computing resources. The WSU Computing Center has avoided considerable additional costs in the form of duplicate management, systems, and operations staff. In addition, in the remote environment it is advantageous to recruit, train, and manage one specialized computing center staff rather than two. With a combined center there is more interaction, understanding, and less suspicion between administrative and academic users. Both faculty and administrators are interested in the support and improvement of the same computing center. More and more computing center management suspects that any division of computing center functions should be based on type of computing (interactive versus batch) rather than organization (administrative versus academic). For example, many research projects are doing processing which has high input/output, low CPU requirements, while many administrative offices submit FORTRAN jobs or use interactive computing. If the WSU Computing Center starts utilizing more than one computer, the second computer will most likely be used for back-up and overload, or jobs will be assigned to the two computers by type of computing required rather than by application type.

# Chapter 6

## Technical Effects of Delivery Modes

### Technological Effects on Modes of Delivery

**by Clair G. Maple**

#### CENTRAL PROCESSORS

During the past twenty-five years the computer industry has grown from an infant nurtured on the existing technology of the late forties and early fifties to a giant depending upon a new technology which has been developed especially for computers. The number of computers has exceeded the wildest estimates of the early fifties when it was expected that just a few of the computers of that vintage could do all the future computations of the world. Figure 1 shows the growth in the number of computers in the United States since 1950. This chart clearly indicates that computers were initially not considered a commercially viable product, and that the early development was largely left up to a few universities. The rather large increase in the number of computers in the 1956 census was due largely to the introduction of the IBM 650 which accounted for better than 80% of the computers existing in that year. This marked the beginning of mass produced computers. Prior to 1956, with a few notable exceptions, computers were usually one of a kind.

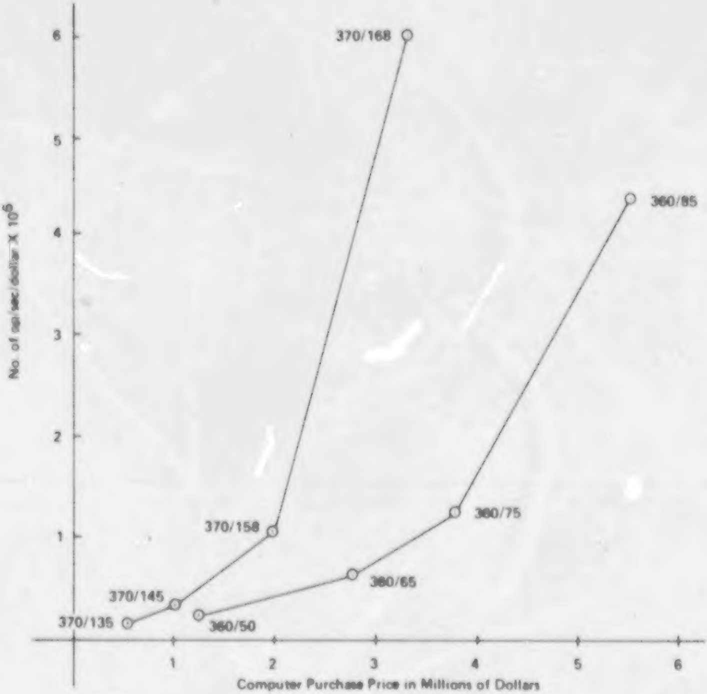
The second point of interest illustrated in Figure 1 is the rather rapid increase in the number of computers from the middle sixties to the early seventies. This period marked the introduction of the minicomputers, and many architectural innovations incorporated in them, as well as the introduction of the third generation of computers.

Figure 1. Growth of Computers

| Year | Non-Commercial | Commercial | Total |
|---|---|---|---|
| 1950 | 6 | | 6 |
| 1952 | 20 | 7 | 27 |
| 1954 | 47 | 60 | 107 |
| 1956 | 51 | 864 | 915 |
| 1964 | | | 17,840 |
| 1966 | | | 38,000 |
| 1968 | | | 50,000 |
| 1970 | | | 76,000 |
| 1972 | | | 110,000 |
| 1973 (Estimate) | | | 135,000 |

From a computation center's point of view, the development of the family concept during the third generation has had a major impact. This concept provides the user with a wide range of performance capabilities which permits the center to upgrade its installation with a minimal impact on the users. As the various members of a family of computers are developed, the manufacturer takes advantage of the newer technology to improve performance and drop cost. Generations within families are now classified by the degree to which circuits are integrated. Computers are usually referred to as: Large Scale Integration (1000 circuits on a chip); Medium Scale Integration (500 circuits on a chip); and Small Scale Integration (100 circuits on a chip). As the newer members of the family come out, they usually provide more circuits on a chip and shorter distances for the signals to travel. As the manufacturer takes advantage of the newer ideas and developments, there has been some deterioration of the family concept. Yet even in this situation exemplified by IBM's move from the 360 to the 370 series, the idea of maintaining compatibility has been given top consideration. The same change also provides a good example of performance improvement. Greater cost effectiveness is achieved as the newer technology are introduced. Figure 2 clearly shows the cost effectiveness of IBM's computer families.

Figure 2. Cost Effectiveness



## MEMORIES

The word memory has almost become synonymous with core since its introduction in the mid fifties. The diameter of the core has decreased and thus the speed of the memory has increased since its first use until now one commonly sees cores of approximately 10 mils in diameter with fractional microsecond flipping speeds. Further the cost of core memory has decreased from dollars per bit to cents per bit. In the mid fifties and early sixties one was very pleased with computers having 16K to 32K word memories and cycle times on the order of 4 to 10 microseconds. Today one is unhappy unless memories on the order of 100 times that size and speeds 10 to 20 times faster than those above are available. These changes in memory systems have contributed enormously toward improving the throughput, which in many respects is much more important than the improvements in speed mentioned above.

Computer center directors now are witnessing a major change in memory systems. With the introduction of the 370 series, IBM gave its stamp of approval to semiconductor memories or solid state memories on a chip. The potential performance of semiconductor memory is greater than that of core memory and, at the same time, permits much more densely packaged systems primarily because ways are being found to put more and more bits on a chip. Furthermore the cost of comparable memory systems decreases as the move is made from core to semiconductor. A good example of such cost saving is provided by comparing the cost of memory for a 370/155 with that for a 360/65. A drop in cost by a factor of 7 or 8 is evident.

Bipolar semiconductor memories, although more expensive than standard semiconductor memories, are exhibiting fantastic speeds, in the 10 nanosecond range, and have the potential to significantly speed-up throughput performance in newer computers. In fact small bipolar memories have already been used as cache memories in some current systems although their performances are usually in the 50 to 100 nanosecond range which is somewhat less than the 10 nanosecond speed mentioned above.

## PERIPHERALS

Many computer center directors have witnessed a change in computer systems from ones which had only a punched paper input and typewriter like output device to very sophisticated computer systems which have a very large spectrum of peripheral devices. Although there has been a considerable amount of change in the variety of peripherals used over the years, the speed of peripheral devices hasn't changed as radically as has the speed of processors and memories. Card readers and line printers have improved by factors of ten and magnetic peripherals such as tapes, drums and disks have changed by factors of a few hundred. Nevertheless it is very difficult to imagine a modern computer system without an array of such devices.

In the early 1960's the principal back-up for main memories was magnetic tape. However because of poor reliability and the fact that they could not be randomly accessed, they have gradually given way to disks and drums as tapes have been relegated to play the roles of tertiary memories and archival storage devices. The current state of the art in disk technology is exemplified by the IBM 3330 disk system which stores one hundred million bytes (8 bits) of information per spindle and can double this with dual density. The 3340, while storing only 35 million (70 million if dual density is used) bytes of information per spindle, has the added advantage of having both fixed head (drum like) and moveable head technology available on the same spindle. Furthermore with the 3340 disk information is available within 10 milliseconds at several megabits per second. These types of devices probably signal the demise of the drum as it is known today. Since the cost per bit of drum storage is intermediate to that of main memory and disk, drums are probably on the way out, but it is not clear what the replacement will be, or indeed whether they will be replaced at all.

Because printers clearly have not kept pace with the improvement in central processor performance, today many printers are attached to the same computer. The impact printer, which has made the modern computer center possible, serves well in the current environment as long as paper remains relatively inexpensive. However, with the present paper shortage the price of paper doubled in a relatively short time and has not yet stabilized. Indeed, paper may not be available in the future at any price. This situation creates additional pressure to use microform output as a substitute for paper. Computer Output Microform (COM) units are very effective if one wants to conserve paper and storage space, but do present a problem since COM cannot be easily viewed. COM appears ideal for archival purposes but is somewhat less than desirable for debugging programs.

## COMPUTER NETWORKS

The concept of a network of computers is an idea whose time has come. It appears that both the computer technology and communications technology have developed to the point that the network concept may be one of the most significant developments of the computer field. Universities, especially, view this concept as an ideal way to make computing widely available on neighboring campuses. Initially, a major university with a large computer facility, possibly funded with an NSF grant, has made some of its computing available to neighboring (usually smaller) campuses which aren't as fortunate. Typically, a remote job entry terminal would be installed on the neighboring campus and connected to the university's computer via ordinary voice grade telephone lines. Such an arrangement had the effect of providing the smaller campus with all the resources of the computing facility enjoyed by the university without the attendant large scale financial and personnel commitment. At the same time the use of some of the university's computer capacity by smaller institutions helped to defray the cost of running the university computer center. Such arrangements exist today in great abundance and the literature is filled with the experiences of such consortiums.

In more recent years, a broader concept of a computer network has been developed in which a group of computers are tied together for the laudable purpose of sharing scarce resources. One of the pioneering efforts in this area is the ARPANET developed under the support and the influence of the Advanced Research Projects Agency (ARPA) of the Department of Defense. Most of the nodes are computer centers located at large universities and government laboratories widely scattered across the United States. Each such center has a small computer called an interface message processor (IMP) which interfaces the campus computer to the network. The ARPANET, which has been in existence for several years, has demonstrated the feasibility of such a system to the point where it is now being developed commercially by Pachet Communications, Inc., Telnet, and others.

## MINICOMPUTERS

The advent of the minicomputer in the late sixties has had and will continue to have a tremendous impact on computing. The cost of a small system today is less than one percent of the cost of a computer of comparable capacity of a couple of decades ago. Since minicomputers are low in price, the number of such systems is increasing rapidly (see Figure 1). Minicomputers have been adapted as communications processors replacing the older more expensive and less flexible communications controllers in large computer systems. They have been used as a building block in the construction of an intelligent remote job entry terminal with considerable local computing capability, and they have been put to work in research laboratories to control experiments and act as a data acquisition system. In addition, low cost time sharing systems have been built around minicomputers in several schools and universities.

It is interesting to note that because the technology in use in minicomputers is more advanced than in the large systems, minicomputers are rapidly becoming more capable for less money. If this trend continues, and there is no reason to doubt that it will as micro-programming develops, many of the jobs currently being done on large computer systems may be taken over by one or a group of minicomputers. Large computers will not disappear, but the type of problems currently run on them may change.

# Development of a Minicomputer Network to Improve the Delivery of Computer Services

by James H. Tracey

## INTRODUCTION

Motivation for developing a minicomputer network at UMR was threefold. First it seemed desirable to bring the power of the larger computer, including its storage and peripherals, into the campus laboratories. Secondly, the minicomputer network could provide new and improved input media to the central facility which is an IBM 360/50. Third, older and inconvenient data handling techniques could be replaced with more modern and convenient techniques. Many applications which were using paper tape could be serviced more effectively by direct entry of paper tape into the System 360 instead of converting paper tape to punched cards off-line. The lack of any uniform format or code for the paper tape complicated the problem. The addition of a mark sense card or document reader was also needed for applications such as balloting, surveying and grading of exams. On-line support for a number of high speed interactive graphic terminals was also required.

In addition, many applications which required on-line control and nearly immediate response to real time events could not be serviced by the slow response of a batch environment. This type of application requires the use of a dedicated computer in the laboratory. As a practical alternative, a dedicated minicomputer in communication with a large time-shared central facility could be used to provide the high computing power and fast response time needed for control of real-time events.

A primary factor in the development of a minicomputer network was economy. Other influencing factors related to economy were time and manpower. Since the network was intended to support other projects, the development had to proceed as rapidly as possible so as not to delay these projects. In order to keep the costs low, outside consultants were out of the question and all work had to be accomplished entirely with in-house resources.

These constraints led to the choice of a single front-end processor interfaced to the System 360 I/O channel rather than the use of dedicated hardwired controllers for the high speed data links, paper tape reader, and mark sense card reader. Since the single selector channel on the System 360 was already heavily loaded, it was decided to interface the front-end processor with the multiplexor channel. The front-end processor had to be capable of operation in the byte multiplex mode because there were a number of unbuffered I/O devices on this channel which could not be locked out by burst transfers for any appreciable length of time.

Rather than choose a minicomputer with a specialized instruction set for communication software, it was decided to use a more general-purpose machine since the purchase of three additional machines was being planned for general-purpose laboratory use which included instruction in minicomputer operation and applications. The confusion of having to work with more than one instruction set, different operating procedures, and different utility software would be avoided by specifying all four minicomputers to be compatible.

The criteria of a general-purpose, low-cost computer with an off-the-shelf programmable interface for the IBM 360/50 multiplexor channel and suitable communication peripherals narrowed the field of choices considerably. A Data General Corporation Nova 800 was chosen as providing the highest performance-to-cost ratio.

The Nova 800 is a sixteen bit machine which makes it suitable for general purpose work as well as eight-bit byte manipulation which is characteristic of communication software. Although a machine with more powerful bit and byte manipulation instructions would perhaps have been more suitable for communication programming, none were available in 1972 in the required price range with the desired peripherals.

## NETWORK DEVELOPMENT

Figure 1 is a diagram of the initial phases of the minicomputer network development. It is particularly useful in this discussion because it shows pictorially the evolution of the mini-network in terms of increased and improved data rates and data handling. First the SCC 650 minicomputer and its associated ARDS graphic terminal were connected through a modem and over a 110 baud line through a second modem into the

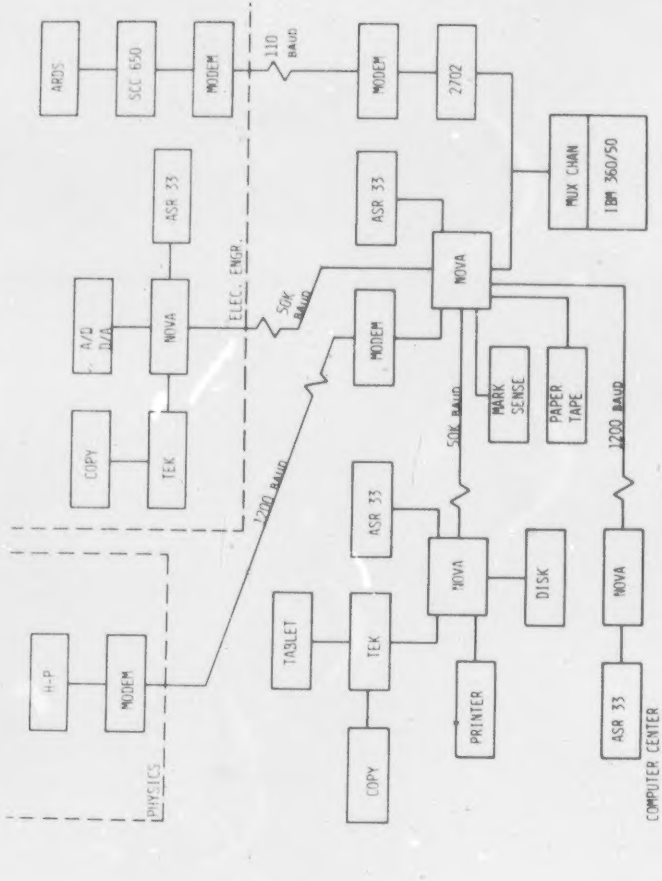

ARDS
SCC 650
MODEM
110 BAUD
MODEM
2702
ASR 33
A/D D/A
NOVA
ELEC. ENGR.
50K BAUD
ASR 33
MUX CHAN
IBM 360/50
COPY
TEK
NOVA
MODEM
MARK SENSE
PAPER TAPE
50K BAUD
1200 BAUD
1200 BAUD
ASR 33
NOVA
DISK
NOVA
H-P
MODEM
TABLET
TEK
PRINTER
ASR 33
PHYSICS
COPY
COMPUTER CENTER

Figure 1. Beginning Network Configuration

multiplexor channel of the IBM 360/50. Preliminary work to support both a remote minicomputer and a computer graphics application was carried out under this configuration. Communication hardware was relatively inexpensive since the modems were acoustic couplers and the 2702 channel adapter was shared between the data link for the remote minicomputer and a large number of typewriter terminals spread around the campus.

The next step was a search for the best technique for increasing the data rate between the remote mini and the 360 computer. Because the 2702 channel adapter was not capable of handling the higher speeds, an evaluation was made to determine whether or not an IBM 2701 channel adapter or a minicomputer would be the best device for supporting a collection of remote minicomputers. For several reasons, including economy and flexibility, a Nova 800 minicomputer was attached to the multiplexor channel of the IBM 360/50. After considerable programming effort it was possible to communicate between the Nova minicomputer and IBM 360/50 as well as to support a remote Nova minicomputer over a phone line at the 1200 baud data rate. In this case the remote minicomputer was also a Nova 800 and the modems were no longer acoustically coupled but electronically coupled.

The next step was to increase the data rates even further to provide faster interaction between the remote minicomputer, its peripherals and the 360/50. The higher data rates required were dictated by the higher rates at which the remote peripherals were capable of accumulating the data as well as the higher degree of interaction required in the applications. Since the campus is a relatively small one it is economically feasible to physically lay cables from remote minicomputer sites to the central Nova. Cable could be laid for distances up to 2000 feet for approximately $500.00. Once cable was laid it was possible to eliminate the modems at both ends of the line and, for approximately $35.00, to convert the electronics at each end of the data links to adequately support the 50K baud rate between the remote minicomputer site and the central Nova.

The communication scheme used throughout, including the 110 baud system, the 1200 baud system, and the 50K baud system is asynchronous. The asynchronous form of communication was chosen primarily because it resulted in considerable savings in hardware between the communication line and the minicomputer, at both ends of all data lines.

A star configuration as opposed to a circular bus was chosen for the minicomputer network in order to facilitate the addition of installations and perhaps tolerate malfunctions in remote installations. This might be difficult to achieve in a circular arrangement where the data for one remote minicomputer may have to pass through hardware associated with a second remote minicomputer.

Figure 2 shows an updated version of the University of Missouri–Rolla

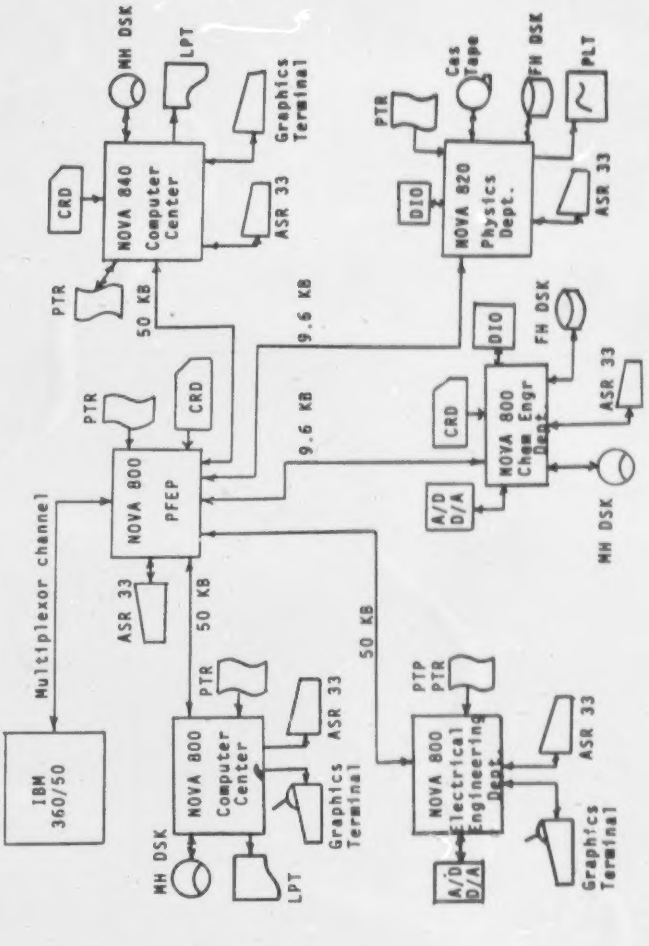

IBM
360/50
Multiplexor channel
NOVA 800
PFEP
ASR 33
PTR
CRD
50 KB
NOVA 840
Computer
Center
CRD
PTR
MH DSK
LPT
Graphics
Terminal
ASR 33
50 KB
9.6 KB
9.6 KB
NOVA 820
Physics
Dept.
DIO
PTR
Cas
Tape
FH DSK
PLT
ASR 33
NOVA 800
Chem Engr
Dept.
CRD
DIO
FH DSK
ASR 33
MH DSK
A/D
D/A
50 KB
NOVA 800
Computer
Center
PTR
ASR 33
Graphics
Terminal
MH DSK
LPT
NOVA 800
Electrical
Engineering
Dept.
PTP
PTR
ASR 33
Graphics
Terminal
A/D
D/A

Figure 2. Current Network Configuration

minicomputer network. The star configuration is clearly identifiable and so are the specialized, laboratory-oriented peripheral equipments such as graphics terminals, A/D and D/A converters, tablets, disks, teletypes, and other data acquisition gear. In 1974, four remote minicomputers are operational and capable of transmitting data to and from the computer center. When the network is completely developed, up to nine remote minicomputers will be connected to serve approximately six remote campus laboratories.

## APPLICATIONS

The majority of applications supported by the minicomputer network fall into categories: data acquisition; preliminary data analysis; and graphics analysis.

At the remote minicomputer, data can be acquired and buffered from a variety of sources which include keyboard, paper tape, an A/D converter, a tablet, a graphics terminal, or direct digital input from an experimental device. Preliminary analysis can be performed in some applications at the remote site to verify the correctness or presence of the data. Then the data can be transmitted in bursts to the 360/50. After the data is analyzed or perhaps used as input to a simulator in the 360, the results of the analysis are then transmitted back to the remote lab where the results may appear on a CRT, the output of a D/A converter, a printer, or a paper tape punch. The only difference in most of the applications is the data rate required to enable the user to work interactively with this system or get data back fast enough to alter parameters of an ongoing experimental system. In parallel with data acquisition and analysis operations one can use peripheral devices in the computer center which are not available at the remote sites including: a Calcomp plotter; the data storage disk; data card punch; and a high-speed line printer.

The minicomputer network provides a means for handling a wide variety of field and experimental data. Data may originate in the form of analog signals, paper tape, oscillograph records, mark sense cards and pictures constructed on a graphics terminal. Such data forms can be conveniently entered into the computing system for analysis followed by a wide variety of storage and presentation methods. One interesting example consists of a geophysicist who acquires data in the field via a minicomputer system with disk. The data disk is then removed from the mobile system and inserted into a remote minicomputer in the network through which the data is entered into the 360/50 for processing and plotting.

The first applications brought up on the minicomputer network were in the computer graphics area. This is one major continuing application area that required a high degree of interaction between the user and the computer system. Perhaps this application, more than any other, requires relatively high transmission speeds to the central facility, high priority rapid processing on the central facility, and rapid transmission back to display a screen of information which shows in pictorial form the results of the analysis on the central facility. A classic example in one of the early applications is a display of a picture of a circuit on the screen of a remote CRT, translation of the picture into data sets at the remote Nova, transmission of the data to the 360/50, and input of the data to a circuit analysis program. The circuit is analyzed on the central facility and the results, in the form of time plots of currents or voltages or frequency plots, are transmitted back to the remote minicomputer which supports the line drawing of the voltage, current or frequency display on the graphics terminal.

A network of like minicomputers has been a distinct advantage at UMR. Not only are disk cartridges easily exchanged as in the geophysics application, but the easy exchange of computer hardware, peripherals and software has been a tremendous advantage which has also significantly reduced maintenance costs. Both hardware and software maintenance can be handled by one full-time person.

When the minicomputers are not operational in the network configuration, they are available as stand-alone units. Again, there are significant advantages to having a collection of like machines. A block of machines can be scheduled at regular laboratory meeting times. In addition, a student may receive instructions on a minicomputer located in the computer center, but, if she or he needs extra time, can use a machine located in a department such as Physics.

## CONCLUSION

The minicomputer network at the University of Missouri–Rolla has proved to be an efficient and modern method for better delivery of computing services to users. At UMR the equipment is adequately serving the dual purpose of: supporting laboratory activities where the computer itself is secondary to the experimental project; and providing hands-on equipment to directly support instruction programs in computer hardware and software design.

# Technology Impact on Computer Services

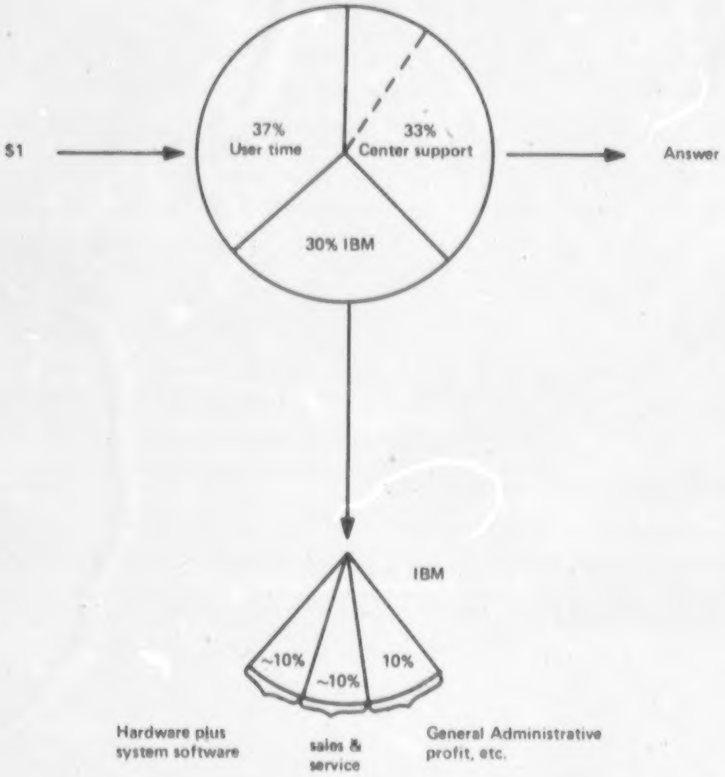
by Arthur V. Pohm

Early in the history of computing, technologically feasible machinery was both relatively simple and expensive. As a consequence, such machinery could be economically applied with most advantage to large scientific problems. Because equipment provided the dominant costs associated with such computating, obviously the equipment was regarded as the main resource to be conserved, and multiprogramming, time sharing, remote job entry stations and other ways to keep such machinery busy were encouraged.

Because the rate of technological progress has been immense in the past two decades, the cost of computing equipment per computation has been reduced by two or three orders of magnitude. However, the cost of providing the human resources associated with such machinery has not. As a consequence, for many problem environments, equipment costs represent only a small fraction of the cost of providing computational services in a typical computation center. Figure 1 illustrates cost estimates of how an individual spends a computing dollar at the Iowa State University computation center. These estimates clearly show that, for most problems, in order to reduce computing costs computing facilities must be simple and convenient to use, simple to access, and must involve a reduction in the required support level.

Although in its infancy, it is apparent that the era of "personalized computing" is upon us with the introduction of calculators such as the

**Figure 1. Cost breakdown of "average" computational service cost at I.S.U.**


$1
37%
User time
33%
Center support
30% IBM
Answer
IBM
~10%
~10%
10%
Hardware plus
system software
sales &
service
General Administrative
profit, etc.

HP-35, HP-65, SR-50, and HP-80 and the desk top calculators. Although these machines have cumbersome I/O and limited storage, they have proven to be immensely convenient and cost effective for many problems even though they typically are idle most of the time. It is also apparent, that additional storage and I/O equipment can be included in portable, desk top calculators. Already experimental calculators have been announced which directly implement APL. At the expense of generality, these machines provide simple convenient, information processing with a minimum of external inconvenience.

Minicomputers, although employing conventional primitive machine instruction, have found immense application in dedicated problem areas. Prices of some varieties are less than a good oscilloscope. Minicomputers are now routinely incorporated in the design of many complex instruments and are rapidly providing performance level which a few years ago were characteristic of medium scale computers. However, the minicomputer market is being rapidly displaced upward by introduction of microcomputers which provide even lower cost alternatives for small applications. One might call this rapidly growing major application area of mini and microcomputers "dedicated computing".

Although it was earlier envisioned that almost all problems could be economically attacked by a large central system communicating with many terminals through telephone lines or other communication links, it is now apparent that small computer costs are low enough in relation to communication costs, that a great many problems will be solved by dedicated computing or personalized computing.

The role of the computing center will involve more emphasis on solving big problems and providing support to peripheral personalized computing or dedicated computing when needed through appropriate communication nets.

# Technical Effects of Modes of Delivery at the University of Nebraska

**by Thomas Michels**

Technical effects of modes of delivery of computing have been primarily evident in the development of the Computer Network at the University of Nebraska. The University of Nebraska has three campuses, two in Omaha and one in Lincoln. In Omaha is the University of Nebraska at Omaha (UNO) with about 14,000 students, and the University of Nebraska Medical Center (UNMC) which has about 1,600 students in various health related programs. In Lincoln is the University of Nebraska at Lincoln (UNL) with about 22,000 students.

Previous to 1971, when the University was reorganized into its present form having the three campuses, the school at Omaha was owned by the City of Omaha and was not part of the University System. The Medical Center, also located in Omaha, was not a separate campus but was a college of the University of Nebraska, which was considered to be in Lincoln at that time. In the reorganization an attempt was made to provide better computing facilities and services for the newly designated campuses and, thus, the University of Nebraska Computer Network was formed with three nodes.

## HASP NETWORK

An IBM 360/40 was installed at the Medical Center and an IBM 360/30 was installed at UNO to create what is now called the Omaha Computing

Facility. The third node, already in existence in Lincoln in 1971, had a 360/65 system which provided remote job entry and time sharing facilities for nodes around Lincoln.

Both regional and local control was established by setting up the offices of Director of the Computer Network and Directors of each Computing Facility. Two major decisions were made at this time also, which greatly affected the running environment. One was that these systems had to take on the administrative data processing load requirements of the university as well as the previous educational and research computing loads. The second decision was that computer access should be set up so users at UNO could run jobs on the larger systems at UNL and UNMC. Previous to this time, all ADP work was done under separate departments not administratively connected with academic computing.

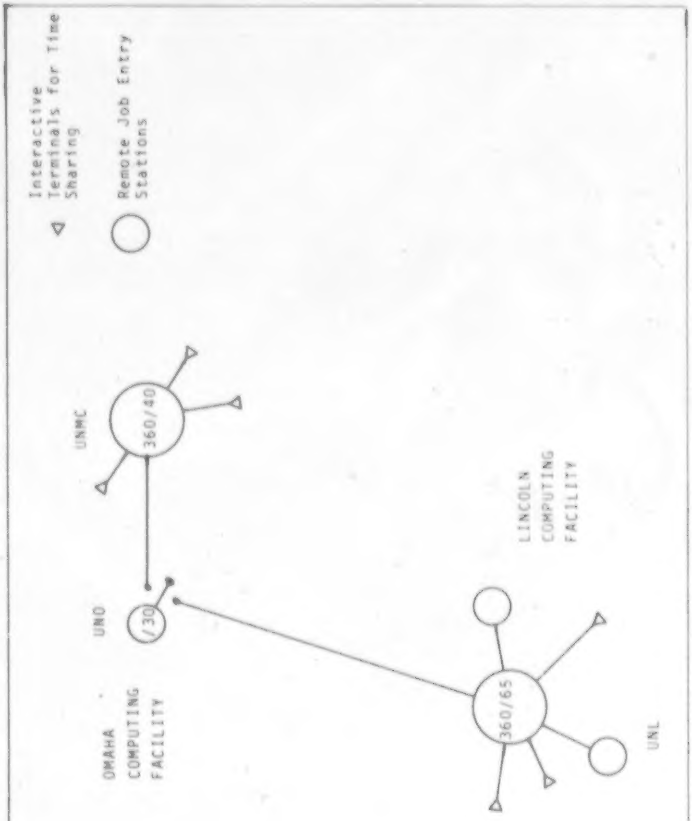
Since both the 360/40 at the Medical Center and the 360/65 at Lincoln were running HASP software, which allows efficient RJE facilities, the necessary communications linkages were installed to allow the UNO 360/30 to be attached as a HASP terminal to alternately enter jobs into either machine. Figure 1 shows this double star-like HASP network.

Because of the RJE facilities developed at UNO and the fairly sophisticated computing services available on the IBM 360/65 at UNL, much of the ADP and educational requirements at UNO began to be processed in Lincoln. This was the start of many changes that were to be made in computing policies and philosophies within the University.

Due to the establishment of intercampus computing, a number of management decisions were necessary in the network operation to decide where certain ADP files should reside, and how to split ADP loads between computing facilities. Network accounting procedures had to be developed and intercampus documentation was required to describe the software available, the operating systems, and the operating procedures at each facility. Also, much communication was required between systems and operations staff to keep each computing facility informed of each system's present status.

Although the network functioned well technically, there were a number of disadvantages to users in Omaha. Users at the Medical Center wanted to be able to use the facilities at UNL. To satisfy their desires, a courier service was set up to transport jobs to and from UNO. Users at both UNMC and UNO wanted to know the schedule, which was irregular, of jobs scheduled to be run at either machine and there were many complaints about lost programs and slow turnaround times from both Omaha campuses. The attachment and detachment of the 360/30 to the 360/40 and 360/65 was done by operators who physically removed a cable from one modem and reattached it to another modem. Although this worked fairly well and provided good service, it was not the best procedure. Also, by 1972 little processing was done on the 360/30, since most of the time the system was used as a HASP RJE terminal.

Figure 1. HASP Network at University of Nebraska (Pre-1973)


OMAHA COMPUTING FACILITY
UNO
/30
UNMC
360/40
LINCOLN COMPUTING FACILITY
360/65
UNL
Interactive Terminals for Time Sharing
Remote Job Entry Stations

## HASP TO HASP NETWORK

In 1972 a new effort was made within the Nebraska network to provide the most convenient access to computing facilities for all users in the university. To take advantage of the simplicity of operation of the HASP to HASP net which existed between the University of Iowa and Iowa State University, the software modifications to HASP were obtained to develop a HASP to HASP network within the University of Nebraska.

The network, which was implemented with a few modifications to fit the Nebraska computing environment but with a minimum amount of communications linkage changes, has been functioning very well since early 1973. Figure 2 shows this net. Two host nodes, the 360/40 at the Medical Center and the 360/65 at UNL each have star-like nets providing both RJE and time sharing capabilities. The 360/30 at UNO was stripped of most of its peripherals (which were owned and were dispersed around the net) and is presently being used only as an RJE terminal to the 360/40.

Anyone using the net can input jobs from any node within the net, whether it is a host node or an RJE node, and run them on either host. After execution, the output can be routed to either host node or any RJE node within the net. The routing of the job is accomplished by the use of control cards inserted into the user's deck by the user. The user has complete control over where s/he wants the deck run and the output printed. The net does not have automatic load leveling, although it was considered. Most of the time sharing facilities shown were available before the HASP to HASP development.

Figure 3 which shows the network in more detail, illustrates how the communications linkages are set up. They are fairly simple and have normally had only minor problems. Backup has been provided, however, using a Network Control Switch (NCS) which interfaces with RJE nodes to the IBM 3705 and CC-70 communications controllers attached to the 360/65.

Because network staff keep fairly tight bookkeeping records of communication line utilization, especially over the Lincoln-Omaha line, they have been able to schedule the routing of long sets of output during low use periods. This has been especially useful in some ADP applications.

## OTHER EFFECTS

Other prime effects resulting from the present mode of computing in Nebraska are not unique to a networking environment, but at times have caused considerable problems within the network. It is important to point out in this respect, that since the net is fairly small geographically and all

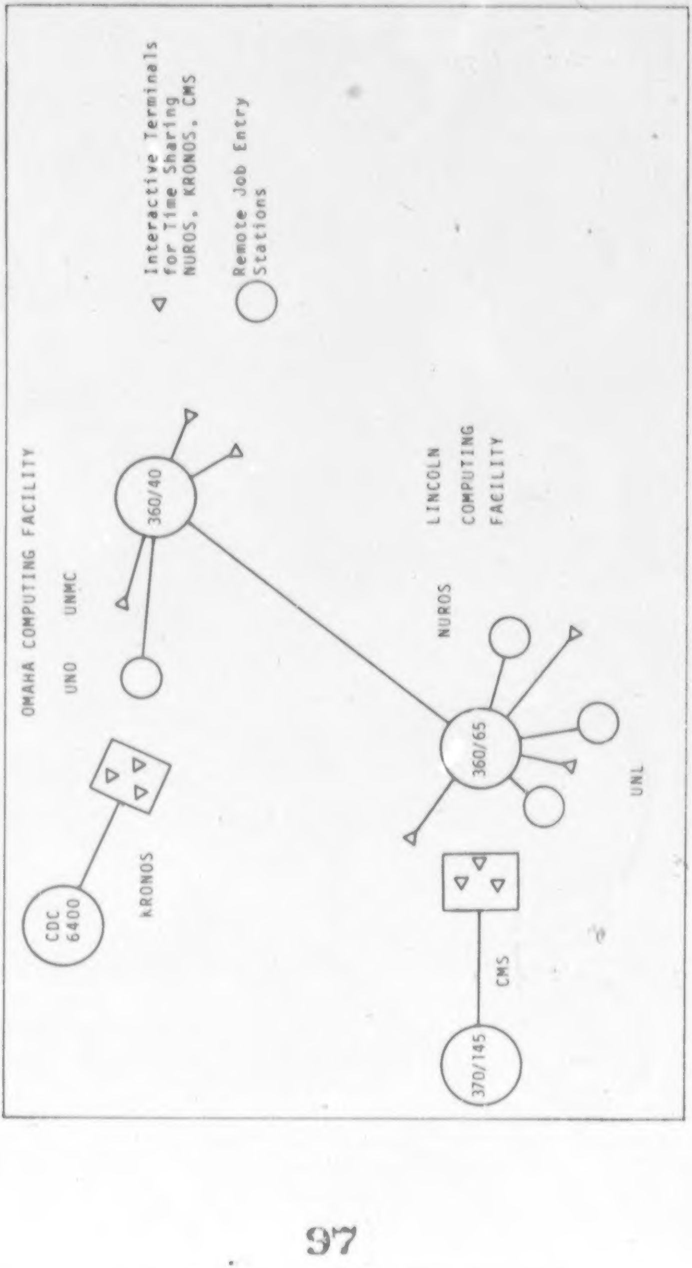
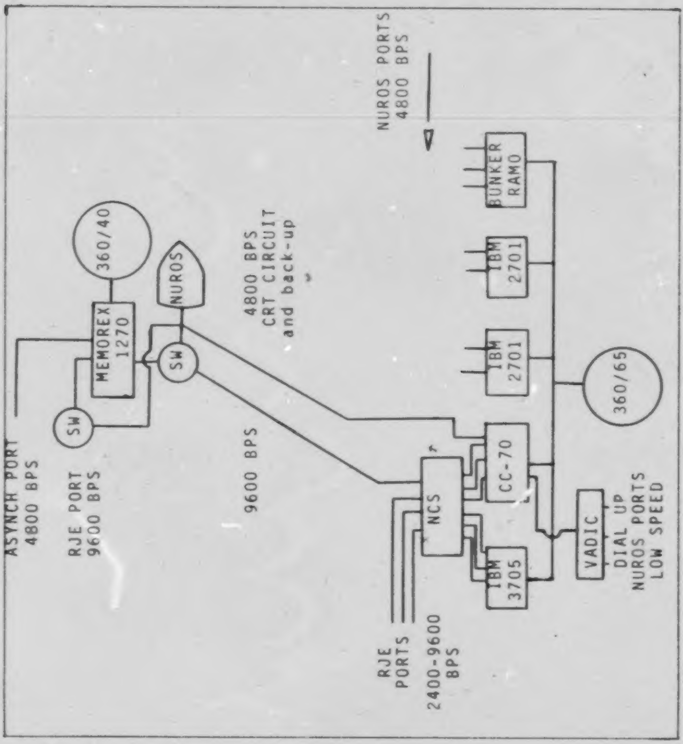

OMAHA COMPUTING FACILITY
UNO
UNMC
360/40
CDC 6400
KRONOS
LINCOLN COMPUTING FACILITY
NUROS
360/65
UNL
CMS
370/145
Interactive Terminals for Time Sharing NUROS, KRONOS, CMS
Remote Job Entry Stations

Figure 2. HASP to HASP Network – University of Nebraska

Figure 3. Communications Network — University of Nebraska


ASYNCH PORT
4800 BPS
RJE PORT
9600 BPS
SW
MEMOREX
1270
360/40
SW
NUROS
4800 BPS
CRT CIRCUIT
and back-up
9600 BPS
NUROS PORTS
4800 BPS
RJE
PORTS
2400-9600
BPS
NCS
CC-70
IBM
3705
IBM
2701
IBM
2701
BUNKER
RAMO
360/65
VADIC
DIAL UP
NUROS PORTS
LOW SPEED

under one University System, network staff have been able to make some policy decisions on computing with less effort than other nets not having this advantage.

Intercity computing over the network required very well defined operational procedures and documentation in the areas of systems, operations and user interface. Before the network development, each computing center had its own small, well-knit group in which each person knew what the other was doing, and word of mouth communication between the computer center and the rest of the campus seemed to be sufficient in many instances. With the development of the network, each facility had to publicize to the remote campuses what was general knowledge within the local campus. A lot of time and money was spent to generate network user manuals and facility guides, and a Network User Services Group was organized which is composed of seven full-time people at work in several user interface functions.

Because of the networking environment, accounting procedures had to be refined to satisfy budgetary requirements within the University System and within campuses. A hard charge policy has worked out quite well since the objective was not to limit computer usage but rather to have some control of the usage. Departments normally get all the computing they desire but, those who may have been abusing use of the computer have begun to think in terms of being a little more efficient in their computer usage.

Another situation that arose because of the HASP to HASP environment was amusing to network staff but not to the user. Previous to development of the net there was never a case when someone ran the same program on both the 360/65 and the 360/40. Now, however, because of the convenience afforded by the net, people have run the same program at each host node and at all times have been charged widely different rates because of the differences in the charging algorithms in each system. The problem really came to light when one user was charged $250 on the 360/65 and close to $1500 on the 360/40 for the same program. Needless to say, this gentleman was quite upset. Since he carried some weight in the university and because we did not have a good answer for him, staff proceeded to develop a charging algorithm that would make the running of a job approximately the same on either machine. This was done effectively because the network was all one University System running under one regional control.

Finally, because of network development, the campuses have been able to get along with less computing power at each campus and access to either host node by all people within the network. Although there is not any more total computing power within the network, the existing power is more efficiently used. The university still has a long way to go to determine the best separation of function for the computer. However, the network has been able to provide better computing power, especially for the people in Omaha and has been able to provide better turnaround time for these people as well. As a whole, the users are more satisfied with the computing facilities provided.

# Chapter 7

## Supplier and Consumer Perspectives

### Southwest Regional Educational Computer Network

by Charles H. Warlick

The Southwest Region Educational Computer Network (SCREN) was first established July 1, 1969, by eight colleges and universities as an experimental project in cooperation with the National Science Foundation (NSF).* The University of Texas at Austin acted as coordinator in developing the network and serves as the lead institution in providing remote computing services and in coordinating curriculum development programs. In the Southwest Region Educational Computer Network, nine four-year colleges and universities and ten secondary schools have enrollments which vary from 225 to 40,000 students. All the colleges are coeducational, offering baccalaureate programs in the arts and sciences. Five are church-affiliated, three are state-supported, and one is private. One secondary school is church-affiliated and nine are public (See Figure 1).

The University of Texas at Austin, as the lead institution of the network, is well-equipped and well-qualified to provide central computer services and curriculum coordination and support. The UT–Austin

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*The materials presented in this paper have appeared in large part in the "Southwest Region Educational Computer Network Final Report 1969-72" presented to the NSF. The report is not copyrighted and is in the public domain.

Computation Center has 16 years of experience providing for academic computing needs, and the Computer Sciences Department has degree programs for Bachelors, Masters and Doctor of Philosophy degrees. The Computation Center staff and the Computer Sciences Department faculty provided the essential resources which permitted The University of Texas at Austin to undertake its role as the lead institution in the network.

**Figure 1. Participating Institutions**

| Name | Location | Faculty | Students | Affiliation |
|---|---|---|---|---|
| Abilene Christian College | Abilene | 181 | 3,200 | Church Affiliated |
| Angelo State University | San Angelo | 150 | 4,200 | State Supported |
| Baylor University | Waco | 394 | 7,750 | Church Affiliated |
| Huston-Tillotson College | Austin | 64 | 750 | Church Affiliated |
| Rice University | Houston | 390 | 3,163 | Private |
| St. Edward's University | Austin | 92 | 900 | Church Affiliated |
| Southwest Texas State Univ. | San Marcos | 386 | 9,800 | State Supported |
| Texas Lutheran College | Seguin | 63 | 1,000 | Church Affiliated |
| Univ. of Texas at Austin | Austin | 1,800 | 40,000 | State Supported |

## OBJECTIVES OF THE NETWORK

Computer science as a discipline and computer methods in other disciplines are relative newcomers to the college campus. The introduction of computer science and computer methods into the college curriculum has required the presence of adequate computing facilities. For those educational institutions without adequate computing facilities and without sufficient funds to acquire them, remote computing services through a network offers a possible compromise. Thus, the network came into existence, using the extensive remote computer capabilities at the UT–Austin Computation Center.

The Southwest Region Educational Computer Network has as its primary objective the augmentation of the curricula of the network schools by adding computer science courses and by introducing computer methods into established programs. A second objective is installation of the necessary computer terminals, communication links, computer hardware, software systems and computer program libraries to support the curriculum development activity.

## HARDWARE CONFIGURATION

*Central Facility.* The central computing system for the network (see Figure 2) consists of a CDC 6600 computer with 131,072 (60 bit) words of central memory, and a CDC 6400 computer with 65,636 words of central memory, linked via 500,000 words of extended core storage. The 6600 has ten peripheral processors with 4,192 (12 bit) word memories, and the 6400 has seven peripheral processors. The peripheral processors perform all system functions except the actual logic and arithmetic functions of the two central processors.

Peripheral devices include: two card readers (1000 cpm); three line printers (1200 lpm); a card punch (250 cpm); five million characters of fast access extended core storage; 620 million characters of disk storage; six 120 KCS tape units; a 30" zip mode plotter; and two operator's consoles. Communications multiplexers and a front-end MODCOMP III communication processor provide remote access channels at: 40,800 bps (4 lines); 2400-9600 bps (32 lines); and 110-1200 bps (128 lines).

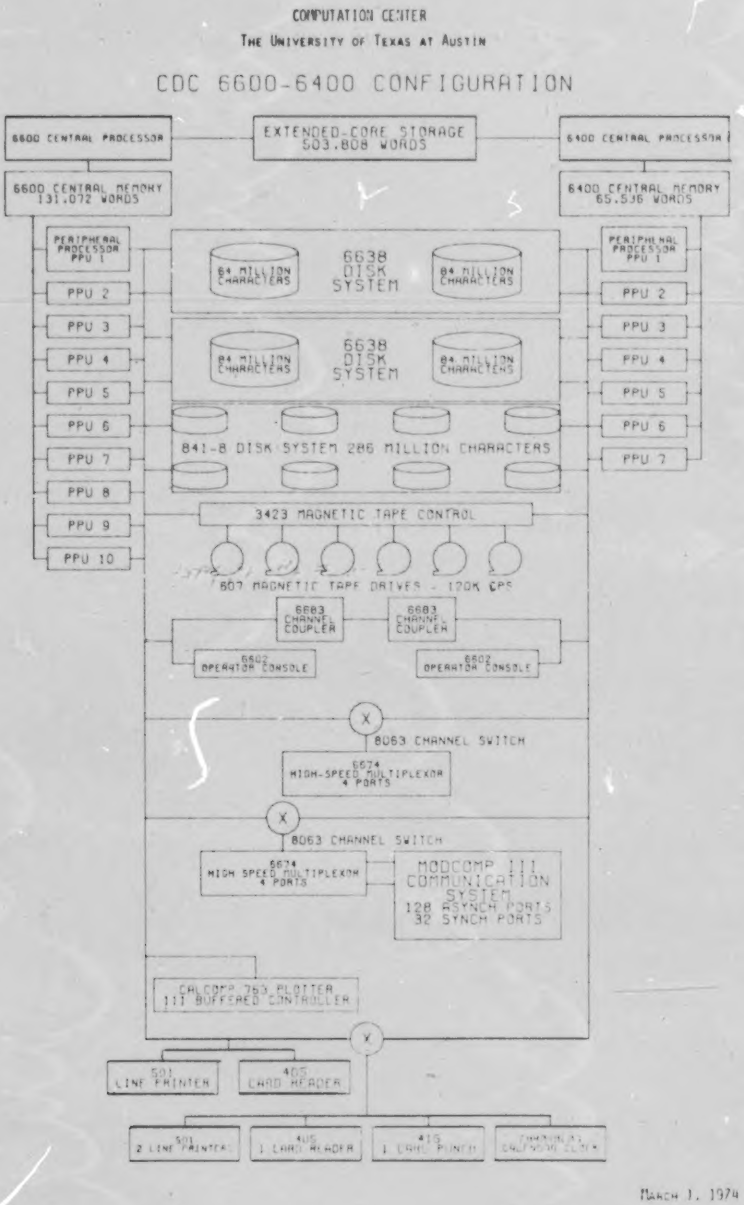
## LANGUAGES AND SERVICES

*Languages.* The UT–Austin Computation Center 6600/6400 computer system offers a wide array of programming languages, including FORTRAN, ALGOL, COBOL, SLIP, LISP, SNOBOL, SYMBAL, SCALLOP, L6, MIXAL, and BASIC.

*Operating System.* Using computation center systems staff, the UT-2D operating system at UT–Austin has been fully developed as an outgrowth of the manufacturer-supplied operating systems SCOPE 2.0 and MACE. Compatibility with 6000 series operating and programming systems developed by the manufacturer and by other 6000 series users has been maintained insofar as possible.

A preemptive-resume scheduling feature enables the system to automatically schedule jobs according to the resource demand (cost) of the job. With cost defined as the product of the computer time remaining for the job, times the core required to run it, the lowest cost job in the system is run first. If a job is in execution at a control point when a lower cost job arrives, the higher cost job is interrupted and rolled out to extended core storage and the lower cost job is brought into central memory for execution. This feature has increased the computer processor efficiency from approximately 65% to approximately 85%. Because students' jobs

Figure 2.


COMPUTATION CENTER
THE UNIVERSITY OF TEXAS AT AUSTIN
CDC 6600-6400 CONFIGURATION
6600 CENTRAL PROCESSOR
EXTENDED-CORE STORAGE 503.808 WORDS
6400 CENTRAL PROCESSOR
6600 CENTRAL MEMORY 131.072 WORDS
6400 CENTRAL MEMORY 65.536 WORDS
PERIPHERAL PROCESSOR PPU 1
PPU 2
PPU 3
PPU 4
PPU 5
PPU 6
PPU 7
PPU 8
PPU 9
PPU 10
6638 DISK SYSTEM
84 MILLION CHARACTERS
84 MILLION CHARACTERS
6638 DISK SYSTEM
84 MILLION CHARACTERS
84 MILLION CHARACTERS
841-8 DISK SYSTEM 286 MILLION CHARACTERS
3423 MAGNETIC TAPE CONTROL
607 MAGNETIC TAPE DRIVES - 120K CPS
6683 CHANNEL COUPLER
6683 CHANNEL COUPLER
6602 OPERATOR CONSOLE
6602 OPERATOR CONSOLE
X
8063 CHANNEL SWITCH
6674 HIGH-SPEED MULTIPLEXOR 4 PORTS
X
8063 CHANNEL SWITCH
6674 HIGH SPEED MULTIPLEXOR 4 PORTS
MODCOMP III COMMUNICATION SYSTEM 128 ASYNCH PORTS 32 SYNCH PORTS
CALCOMP 763 PLOTTER 111 BUFFERED CONTROLLER
X
501 LINE PRINTER
405 CARD READER
501 2 LINE PRINTERS
405 1 CARD READER
415 1 CARD PUNCH
MARCH 1, 1974

tend to be low cost, their programs are given highest priority. However, the higher cost jobs provide background computing demand and the turnaround time of higher cost jobs is minimized.

*Remote Terminal System.* In March, 1967, the Computation Center initiated timesharing service to the Austin campus with the installation of the RESPOND System. After executing 264,000 timesharing jobs over 36,000 user hours, RESPOND was replaced by TAURUS, the Texas Anthropocentric Ubiquitious Responsive User System. As an integral part of the Computation Center 6600/6400 dual operating system, TAURUS provides a highly reliable and powerful timesharing service. The three components of the timesharing service, terminal communications, file editing, and file storage, were implemented in a modular fashion under the UT-2D operating system. Any user who knows how to use the computer in batch mode is able to use TAURUS with little further instruction. However, TAURUS allows the sophisticated timesharing user to interface with the computer in an extremely powerful fashion. TAURUS accepts a large variety of console terminals and supports graphic terminal devices by providing a fully transparent, binary read and write capability. With the installation of UT-2D and TAURUS, the computation center moved another step forward in providing complete, state-of-the-art computational services to the educational community.

*Communications.* All Network schools except Baylor University and Southwest Texas State University communicate with the 6600/6400 operating system exclusively through the teletypewriter interface. Teletypes are connected to the UT system through a rotary switch which is in turn connected to the MODCOMP III communication processor. This switching system takes care of port contention while the communications driver (TAURUS) handles both character mode and transparent binary input and output. Baylor University and Southwest Texas State University operate PDP-11 computers in remote job entry mode.

All network schools, except the Austin schools and Southwest Texas State University, use GSA telephone lines which reduce line costs considerably. Because of the relatively low line cost and the small number of terminals at each location, line multiplexing was not economical. Southwest Texas State University, however, acquired equipment in November, 1971, that will multiplex one 2400/4800 bps channel with up to six 110 bps teletypewriter channels via a 15,000 KHz microwave subcarrier. The microwave channel is a part of the Texas Educational Microwave Project master channel running from Austin to San Antonio via San Marcos.

No telpak lines or line conditioning are used in the Network.

*Library and Utility Programs.* In addition to the standard mathematical functions, the on-line system library contains several library and utility programs, callable either from a control card or from a user's program (See Figure 2).

In addition to the on-line library described in Figure 3, more specialized programs are accessible from remote terminals and batch jobs. Abstracts of these programs, and others, are listed in a publication, TPA 18, "Program Library Catalog for the CDC 6600 Computer" available from the UT–Austin Computation Center. The program library tape includes a subset of the CDC 6000 series users group, VIM, program library. Programs developed by network participants are made available to other participants by installation in the program library or via the permanent file system.

*Services.* Computing services provided to the network include a full set of access modes and a wide range of software systems: local batch; high-speed remote batch (40.8 KB); medium speed remote batch (2.4-9.6 KB); low speed (110-1200 bps) keyboard terminal interactive access. In addition to servicing the network needs, the computer system also provides general computing service for the educational and research activities of UT–Austin.

*Operating Schedule.* The UT–Austin 6600/6400 computer system operates 24 hours per day, seven days a week.

*Charging Algorithms.* The hourly rate of computer time charge at the central site is determined by an annual cost audit performed in accordance with accepted federal standards. Defined as the sum of central processor time and data channel reservation time, the unit of time charge is called TM or system time. This unit normalizes the measurement of the claims a job places on the system so that the cost of a job is not affected by system loading. The current rate is $260 per TM hour. (The commercial rate for a 6600 system with comparable turnaround is $1,000 per TM hour.)

In addition to system time charges, TAURUS users are charged $0.40 per hour of connect time. (The comparable commercial rate is $8 per hour.)

*Mail Services.* Input mail-in and output mail-out services are provided for users outside Austin who want to run batch programs and do not have a remote job entry terminal. Large card files can be entered through the central site card readers. Bulky output can be directed to the high speed printers at the central site for automatic mail-out. Similarly, all of the other output devices at the central site (plotter and card punch) can be used from remote terminals with the output returned to the user by mail.

*Other Services.* The central site also provides acquisition and warehousing services for remote terminal supplies for the participating institutions. By reducing the requisition procedure to a telephone call, this practice simplifies this aspect of terminal management. Supplies thus ordered are mailed to the requestor, and charges for the supplies included in the monthly invoice.

**Figure 3. SRECN Library and Utility Programs**

| | |
|---|---|
| ALGOL | An optimized ALGOL compiler |
| BASIC | Compiler for the BASIC language |
| CATALOG | Catalogs the contents of a file |
| CLIC | A set of processors for creating and taking courses on the computer |
| COBOL | A COBOL compiler |
| COMPASS | 6600 assembly language program |
| CONTOUR | A contour plotting program |
| DESCAL | A desk calculator program |
| EBCDIC | Translates IBM EBCDIC (System/360) card decks to standard 6600 codes |
| EDIT | Interactive editing system |
| EDSTAT | A sub-library of general purpose statistical routines |
| FORTRAN | An optimized FORTRAN compiler |
| FRED | A BASIC-like language for programming; has a desk-calculator mode |
| L6 | An interpreter for the Bell Laboratories Low Level Linked List Language |
| LIBRARY | Provides access to system sublibraries |
| LISP | An interpreter for the symmetric list processing language LISP |
| MIMIC | A general purpose, engineering-oriented numerical integration package |
| MIXAL | Knuth's assembly language, used in teaching |
| PLT | Plotter package for CalComp 763 plotter and CDC 254 microfilm camera, and TSP 212 remote plotter |
| SYSTEM 2000 | An elaborate general purpose, user-oriented interactive file management system |
| RUN | An object code optimizing FORTRAN compiler |
| SCALLOP | An interpreter for a compiler-writing language |
| SLIP | A FORTRAN embedded list processing language |
| SNOBOL | An interpreter for a string-oriented list processing language |
| SPSS | An elaborate package of statistical processors with data management facilities |
| SRTMRG | Standard, general purpose sort/merge package |
| SYMBAL | An interpreter for a symbolic algebraic language |
| TIDY | Cleans up FORTRAN programs which have been heavily edited |
| TSORT | An in-core sort program |

## NETWORK CURRICULUM SUPPORT

The extension of instructional computing in the network institutions is encouraged by faculty workshops in various disciplines. The workshops usually last two days and are held on the UT–Austin campus. New computer-based educational materials are presented, and the attendees use the materials and programs in laboratory sessions before returning to their own campuses. A network curriculum coordinator is available for consultation as the new materials are used in the classrooms of the network schools.

# TUCC Networking from an NCECS Customer's Point of View

**by Richard Kerns**

The School of Business of East Carolina University became a retail customer of the North Carolina Educational Computing Service (NCECS) through a rather interesting process. In 1972 an IBM salesman approached the Dean of the School of Business with a proposition. In order to allow the school to try out the facilities at the Triangle Universities Computing Center (TUCC) IBM would provide free of charge a model 2770 remote batch terminal and pay communications charges for a trial period of approximately three months. TUCC would provide free computer time on their 370/165 for this trial period. The School of Business accepted this offer, and the equipment was installed in the late spring of 1972. With only a short time left in the spring quarter, it was still possible to have enough experience to discover the benefits from a TUCC connection through NCECS. Following the trial period a decision was made in the summer of 1972 to reacquire a TUCC terminal on a paying basis. However, the usual red tape and delivery problems, it was December before the terminal was installed.

At the same time East Carolina University was in the process of acquiring and installing a Burroughs Corporation B5500 computer, a second generation machine. It was obvious that it would be very difficult and time consuming, if not impossible, to convert the TUCC uses to the Burroughs machine, but since the terminal was not installed, the School of Business was left with no choice but to try to use the B5500. With faculty fears soon found to be justified, minimal use of computing in the curriculum was made until the new terminal arrived.

## ADVANTAGES OF REMOTE COMPUTING

The TUCC terminal offered several major advantages: First, TUCC and NCECS maintain an extensive program library which is continually expanded. Such a library, which is so important to getting faculty involved, could never be had at the local center for reasons of machine capability, personnel capability, and funds. Second, because the TUCC 370/165's offered greater size and speed meant School of Business faculty could undertake projects at TUCC which the local machine could not accommodate. Furthermore, because the School of Business terminal was housed within the business building the terminal staff could give the kind of service desired to students and faculty alike. Faculty of the School of Business could decide which cards would be loaded first, which jobs would have priority, whether to run special forms jobs, if a class could be brought into the room, and so on not the computer center which faced all sorts of pressures from administrative and other academic users. Fourth, hands on use by students contributed to their education. The fellowship holders assigned to run undergraduate programs came away with a much better understanding of computing than turning cards into a dispatcher could ever have given them. Fifth, through affiliation with NCECS, channels of communication were opened between the East Carolina University and other schools in the state and the nation which would not have been opened otherwise. Finally, a combination of business school computer experts and NCECS consultants was able to solve the problems which developed both in hardware and in software with relative ease. The local center could not have devoted people to customer service full time the way NCECS can.

## LOOKING TO THE FUTURE

Because other departments and schools at East Carolina University have seen what the School of Business is doing, there is a strong desire to acquire a TUCC terminal or terminals for the rest of the campus. It appears that TUCC will be used for jobs where it is the most expedient machine to use or where it is the only machine that can be used, and the B5500 will be used where its capabilities in cost, control over peripherals, and security make it the better machine.

The other departments will have to consider several potential problems. It has been relatively expensive for the business school to pay for computer use out of the school budget, but it has been well worth the cost for the reasons outlined above. Because the distance between the terminal user and the decision makers at the central facility is sometimes greater than it should be, the terminal users' needs may not be taken into account even though the decision makers make good attempts at discovering these needs. One user out of fifty does not have a lot of weight when it comes time to decide on a change in central processors for instance. Finally, the requirement of telephone transmission introduces problems in terminal use which sometime make it difficult to locate the cause of problems. Often the telephone company says it is the terminal's fault, and the terminal company says it is the telephone company's fault. Hopefully, as equipment improves this sort of problem will become so infrequent that it will not need to be mentioned. However, presently, transmission problems can mean many hours of frustration to a network user.

In general, the School of Business of East Carolina University has been a very happy customer of NCECS and has been able to provide a much better education to students than would have been possible without such an arrangement.

# A Wholesale/Retail Approach to Delivering Computing Power

**by Louis T. Parker, Jr.**

The North Carolina Educational Computing Service (NCECS) is the central organization for a network of 49 institutions of higher education and 10 high schools in North Carolina which includes public and private colleges and universities, community colleges and technical institutes. NCECS is a retailer of computing service, purchasing computer time from the Triangle Universities Computation Center (TUCC), a non-profit corporation owned and operated by the University of North Carolina at Chapel Hill, North Carolina State University and Duke University. A complete description of NCECS can be found in the Spring 1974 issue of the EDUCOM Bulletin.

Figure 1 shows how NCECS is one of four retailers associated with the Triangle Universities Computation Center, the wholesaler.* The other retailers are the campus computer centers at Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill. Figure 2 shows the geographical locations of the institutions currently served by NCECS. Figure 3 shows the types of institutions which comprise the network.

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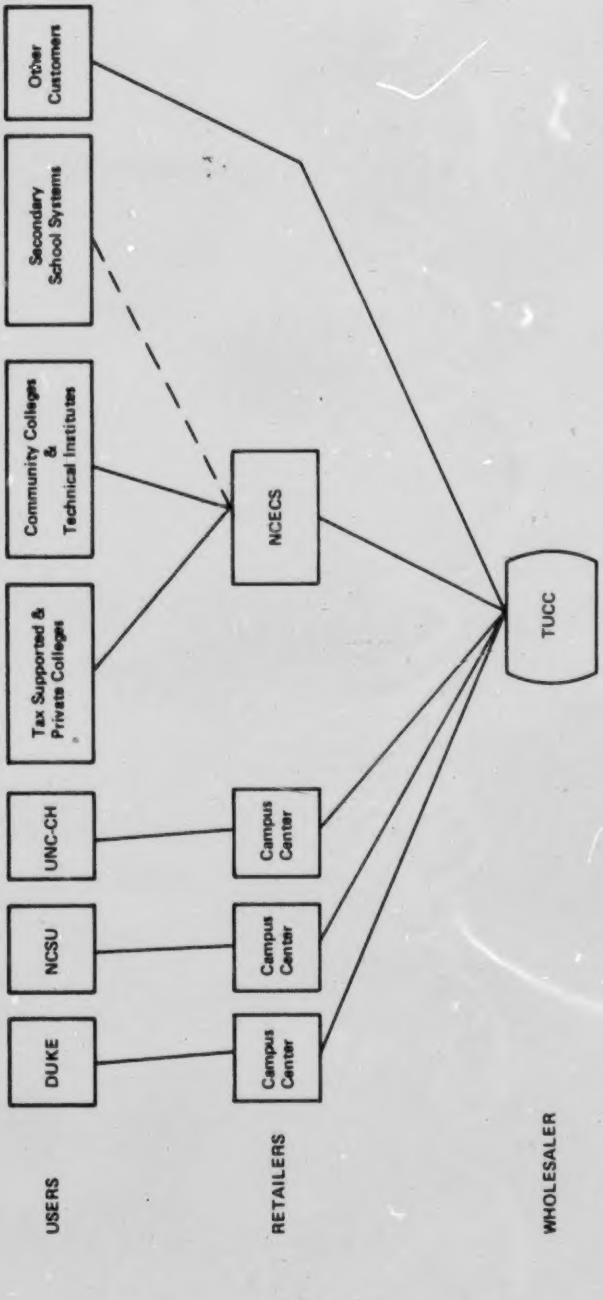
*Figures in this paper are reprinted with permission from EDUCOM, Bulletin of the Interuniversity Communications Council, Inc. Volume 9 No. 1, (see reference 1)

Figure 1.


USERS
DUKE
NCSU
UNC-CH
Tax Supported & Private Colleges
Community Colleges & Technical Institutes
Secondary School Systems
Other Customers
RETAILERS
Campus Center
Campus Center
Campus Center
NCECS
WHOLESALER
TUCC

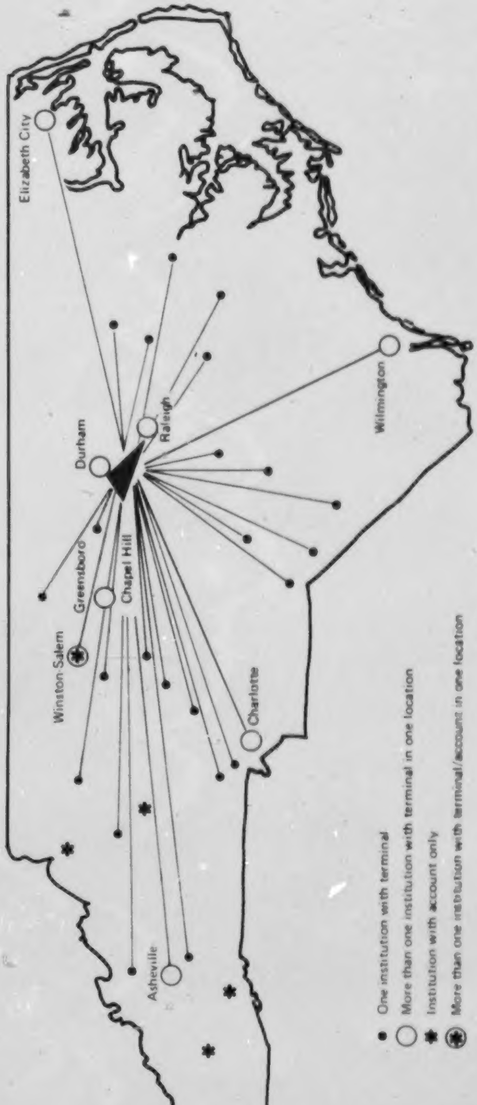

Elizabeth City
Durham
Raleigh
Wilmington
Greensboro
Chapel Hill
Winston-Salem
Charlotte
Asheville
● One institution with terminal
○ More than one institution with terminal in one location
* Institution with account only
⊛ More than one institution with terminal/account in one location

Figure 2. Network of Institutions Served by NCECS/TUCC

Primary job source nodes (high-speed terminals linked by TELPAK-A lines) exist at the University of North Carolina at Chapel Hill, Duke University and North Carolina State University. These universities, the owners of TUCC, have large on-campus computer centers which serve as retailers of TUCC service and interface directly with the central facility.

**Figure 3.**

| *NCECS* Users | With Terminal | With Account |
|---|---|---|
| University System | 12* | 14* |
| Community College System | 22 | 23 |
| Private Institutions | 15 | 18 |
| Secondary Schools | 10 | 10 |
| Other Educ. Organizations | 1 | 2 |
| Totals | 60 | 67 |

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*Includes UNC General Administration and Fort Bragg Extension. Does not include UNC-Chapel Hill or N.C. State University (member institutions of TUCC).

## TUCC AS WHOLESALER

The functions of the wholesaler are:

- Machine Operations;
- Hardware Management – Planning, Financing, Vendor Relations;
- Operating System Maintenance and Development;
- Coordination of Requirements from all Retailers; and
- Publication of Documentation – System Software, TUCC Program Library.

TUCC is concerned primarily with management of the central system hardware and software. The staff consist of systems programmers, computer operators and management. One important function of the TUCC management is to resolve conflicting requirements from the various retailers.

The TUCC three-megabyte IBM 370/165 operating under OS/360-MVT/HASP provides a variety of programming languages for batch use, including FORTRAN IV, PL/1, COBOL, ALGOL, PLC, WATFIV and WATBOL. The interactive services include PL/1, APL, BASIC, and a variety of facilities under the Time Sharing Option (TSO) of OS/360.

## NCECS AS RETAILER

As a retailer of TUCC computer power NCECS performs several functions:

- User Service
  technical consultation as needed (by phone, etc.)
  circuit riding and workshops
  diagnosis and corrective action for telecommunications failures;
- Communications Planning and Management;
- Information Services – Distribution Specialized Documentation;
- User – Level billing;
- User Representation at TUCC (for 59 Institutions); and
- Curriculum Support Services.

Circuit-riding is done on an as-needed basis, but is always provided to institutions when they first join the network. With the current difficulties in obtaining GSA TELPAK circuits to reduce line costs, and the growing use of multiplex equipment, communications planning and management has become an increasingly important function of NCECS.

**Figure 4. NCECS Network Terminals – April 1974**

| Type of Terminal (BAUD) | Number of Terminals |
|---|---|
| Teletype (110) | 32 |
| 2741 (134.5) | 5 |
| 1050 (134.5) | 16 |
| PE8001 (1200) | 12 |
| 2770 (2000,2400) | 8 |
| 1130 (2000,2400) | 3 |
| 2780 & equiv. (2400,4800) | 4 |
| 3780 (4800) | 5 |
| Programmable (4800,9600) | 2 |
| Total Low-Speed | 53 |
| Total Medium-Speed (incl. PE8001) | 34 |

In 1974 NCECS offered a variety of data communication facilities: WATS service (for 6 terminals); five local lines; 29 FX lines; 15 leased lines; 15 multiplexer channels. Aggregate modem baud rate of all lines is 102,729. The different types of terminals at the institutions served by NCECS are shown in Figure 4. With regard to information services NCECS emphasizes *selective* distribution since so much documentation is produced by TUCC, NCECS, and the other three retailers. The NCECS Director represents the network institutions at TUCC, in particular at the regular meetings of the Campus Center Directors and of the TUCC Board and is the advocate of their special needs.

Curriculum support services of NCECS have greatly enhanced the attractiveness of the central facility to the network institutions where the need is for computer applications in undergraduate curricula. Activities of the curriculum development program which are summarized below are described in more detail in the EDUCOM Bulletin[1].

- Services and activities
    - Large library of applications (canned programs)
    - Program and Literature Service (PALS)
    - Documentation, incluidng educational material
    - Support by ECS User Service
    - Faculty workshops

- Disciplines
    - Accounting
    - Biology
    - Business Administration
    - Chemistry
    - Economics
    - Mathematics
    - Physics
    - Political Science
    - Psychology
    - Sociology
    - Statistics

To undertake such a wide range of activities NCECS maintains a significant professional staff. In addition to the Director, NCECS employs: a Development Manager; a Manager of User Services; two computing consultants who function as circuit riders; a Cirriculum Coordinator for the CONDUIT Project; an Administrative Assistant for Curriculum Development; two curriculum development programmers; an Information Services Officer; a Business Officer; and two Secretaries.

Since 1969, TUCC has recognized NCECS as a retailer of its service, adopting a policy of selling machine time to NCECS on a bulk basis, at wholesale rates. The present scheme is based on volume discounts. Receipts from the markup on computer time, made possible by the volume discount received from TUCC, support approximately 25% of the total NCECS budget which includes only costs associated with central staff. NCECS in turn offers a volume discount to its users, with break points at 1 hour and 3 hours of total time use, on a monthly basis. Three campuses served by NCECS now place their own markups on computer time as a way of recovering some of the costs of their local operations.

As the relationship between NCECS and TUCC continues to evolve, the next step should be the annual purchase by NCECS of a share of TUCC capacity, similar in principle to the method which has always been used by the owning institutions. Such an arrangement would involve an annual dollar commitment by NCECS to TUCC. In return for advance commitments, NCECS users should be able to get even more computing for their dollars than they do under the present arrangement. The option of buying on an hourly basis from NCECS would be continued for users who prefer flexibility to advance commitments of their computer time budgets.

## REFERENCES

1. Parker, L.T., and Denk, J.R., "A network model for delivering computer power and curriculum enhancement for higher education", *EDUCOM Bulletin*, Spring 1974, pp. 24-30.

2. Williams, L.H., "A functioning computer network for higher education in North Carolina," *Proceedings of the Fall Joint Computer Conference*, AFIPS Press, Montvale, N.J. 1974, pp. 899-904.

# Network: A User's View

**by Donald L. Hardcastle**

Baylor University is a private, church related university with 8,000 students and 387 faculty members. The university offers six doctoral programs including physics, chemistry, psychology, and education, all of which make extensive use of the computer, and 23 masters programs in addition to many bachelors programs. Present computer usage is equally divided between academic and administrative applications. Of the academic computer time research takes about 60% and instructional usage 40%. A computer science program is now being developed.

Figure 1 illustrates the history of computer hardware acquisition at Baylor University. In each case the option offering the least increase in expenses was chosen.

When considering each hardware purchase, staff operated under two basic administrative guidelines: 1) The University will operate in the black! (Jugbe Abner McCall, President, Baylor University); and 2) The University should not be committed to a large dollar outlay over a long period of time. (Dr. Herbert Reynolds, Executive Vice President, Baylor University). Baylor University is one of the few major private universities which has been able to operate in the black, financially.

**Figure 1. Computer Hardware History**

| Year | Computer Selected | Other Options Considered |
|---|---|---|
| 1962 | IBM 1620 | — — — |
| 1968 | Honeywell 1200 | IBM 360/30 |
| 1969 | Honeywell 1250 (an upgrade) | |
| 1971 | Honeywell 1250 plus Univac 1108 RJE | Upgrade H1250 |
| 1972 | Honeywell 1250 plus CDC 6600 RJE | Univac 1108 RJE<br>IBM 360/65 RJE<br>B 6700 RJE |
| 1974 | Honeywell 1250 plus CDC 6600 RJE and Interactive and Local Interactive BASIC: PDP-11/45 | B 6700 RJE<br>IBM 360/65 RJE<br>H1250 upgrade |

## THE DECISION TO JOIN

It may be instructive to look at several cost factors that helped Baylor to choose the University of Texas network (Southwest Region Education Computer Network) using the CDC 6600/6400 configuration. First, it should be noted that remote batch terminal and modem costs are independent of the network chosen. Telephone line charges are variable, however. For the Univac 1108 Baylor University paid the commercial telephone line rate of \$3/mo./mi. at 100 miles distance, for the University of Texas Network the university pays GSA rates of \$0.62/ mo./mi. at 100 miles distance. The B6700 network involved no telephone line charges.

The cost comparisons noted in Figure 2 were used to select a network. Clearly the CDC 6600 offered the best price performance of the various systems considered.

Another major consideration in choosing the University of Texas network was the availability of interactive capabilities and the decision by the network to use the remote terminal to simultaneously transmit batch and interactive programs. Baylor University considered the availability of interactive capabilities to be a must, in order to offer an essential educational resource to students and faculty.

For the Fall of 1974 the university will continue to use the RJE batch

**Figure 2. Network Cost Comparisons**

| System | CPU Cost per hr. | Relative CPU time for same jobs | Relative Cost for same jobs |
|---|---|---|---|
| U1108 | $650 | 2 | $5 to $8 |
| CDC6600 | $260 | 1 | $1 |
| B6700 | $540 | 2 | $4 to $6 |
| H1250 | $ 37 | 100 | $14 |

terminal and eight interactive TTY's and CRT's scattered across the Baylor campus, all connected to the University of Texas network. During the next year the administration will make a major administrative/academic decision since the Honeywell contract ends in the near future. A major influence on that decision will be experience with new remote interactive/batch software on the U.T. network.

Future options include:

- All remote computing: academic and administrative;
- Remote network computing for academic applications plus local computing for administrative applications to replace the H1250; or
- All local computing with a DEC System 10, a Sigma 7, or similar machine.

Because of Baylor's research needs, it will be very difficult to give up the machine capabilities and software available through the network. Thus, even if the third is chosen, Baylor University will most likely remain with the network for certain research projects.

A summary of 1973-1974 network expenses is given below for comparison. Baylor experience has been that the average CPU cost per student in an introductory programming course is under $10 per semester. During the 12 months period 18,000 jobs were run under the sponsorship of 22 faculty members supervising research projects and 29 faculty supervising instructional applications. The system served 530 student users during 1973-74.

**Figure 3. Batch RJE Operations**

| Type of Usage | CPU Cost/Job | Other Cost/Job (Terminal, etc.) |
|---|---|---|
| Research Usage (60%) | $.44/job | $1.00 |
| Instructional Usage (50%) | $.23/job | $1.00 |
| Average CPU charges/mo.: | $600.00 | |
| Approximate cost per month for terminal, telephone, etc.: | | $1600.00 |

It should be noted that the "Other Cost/Job" (terminal – telephone – etc.) identified in Figure 3 decreases with increased usage since these are fixed expenses.

In March, 1973 Baylor installed a PDP-11/45 system as the RJE terminal at a purchase price of $46,000. A savings of approximately $6000 could have been realized by using a smaller CPU (PDP-11/40); however, the administration felt the potential offered by the one chosen was well worth the added expense. Our yearly budget (1974-1975) for academic usage of the network is $35,000 which includes: $8,500 for purchase of new equipment (CRT's and local dial up telephone modems for 1973-74); terminal maintenance; telephone modems (4800 baud); CDC 6600 CPU charges; lease for five teletypes; lease of 4 card punches; and supplies. In addition to the batch RJE terminal, this budget will give five TTY's and three CRT's, each with a dual tape cassette unit.

Baylor University joined the network by choice, without any outside funding or incentive, and without any internal administrative pressure. The original members of this network did receive some outside funding. The choice was made by the academic computer users in order to meet increasing computer needs. Major considerations in the decision to join were:

- Economics
  Short term dollar cost.
  Long term (yearly) dollar cost with expanded usage.
- Utility
  Accessibility: terminal types (RJE and interactive) and locations.
  Versatility: software, languages, plotters, etc.
  Speed/size: turnaround time, core size.
- Future Flexibility
  Several options open.

At this time the administration is considering and testing the possibility of performing some administrative work through the network.

Experience with the network has been good. Program turnaround time is considered excellent with turnaround on student batch programs of 15 to 30 seconds, on research batch programs of five to ten minutes for most, and one second for interactive response.

## BENEFITS AND PROBLEMS

Other benefits are from the network which would not be available from a local center. Extensive software is available from the UT–Austin computer center. The network is a member of CONDUIT. At the UT–Austin computer center interactive connect time charge is 50 cents/hr. while commercial rates are $5/hr. The University of Texas Computation Center Staff has been very helpful to remote users, and telephone consultation has been available on software and hardware problems when needed.

Baylor faculty have encountered a few problems or potential problems. In bringing up the new terminal a three-month delay resulted when an incompatability was discovered between the network developed terminal software and the purchased DEC hardware. Network staff spent four weeks rewriting the code to solve the problem. Although it is unlikely, the network could make some major changes, forcing remote users to change at their expense. The Baylor University contract specifies that the University of Texas users have first priority on usage. Although this has not affected usage to date, it might be a problem in the future. Although rendered willingly, consultation by telephone on complicated software packages is not the most effective help. Another problem is the high cost of data storage. Tape and disk usage on the CDC6600 can become expensive. (Some SPSS runs have cost $9.00/job.) Finally, possible administrative usage of the network has not yet been tested.

In general, the benefits far outweigh the problems. The Southwest Region Education network is satisfying Baylor University's immediate needs and the choice to join the network has proven to be the best choice. In 1974, networking is now an effective, efficient means of obtaining necessary educational computer resources.

# UNI-COLL/Penn Relationship: The UNI-COLL View

**by H. William Knapp**

This paper describes the genesis of the UNI-COLL Corporation from the University of Pennsylvania Computer Center, the mode in which computing services are delivered to the academic community in the Delaware Valley by the UNI-COLL Corporation, and the nature of the services that UNI-COLL provides.

The UNI-COLL Corporation was established on June 21, 1971 as a consortium of colleges, universities, and medical institutions in the Delaware Valley. The corporate objectives are:

- To provide a shared, regional computing facility which delivers service at a level of sophistication, breadth of scope, and degree of technical competence beyond that achievable by the individual user;
- To provide effective management of the computing resource through control of user access and detailed reporting on the types and distribution of usage;
- To reduce development and implementation costs for administrative applications through the availability of data base management tools, and the sharing of software packages, experiences, and expertise;
- To provide a basis for the development and dissemination of computer systems for education;
- To provide an extensive repertoire of language compilers, programs, and subroutine libraries for the batch and interactive user; and

- To facilitate computer usage through a central source of customer information in the form of an ongoing education program, computer system documentation, and publications (e.g., newsletters, memoranda, manuals, etc.).

## HISTORY

The UNI-COLL installation, which currently houses an IBM 370/168, began its career as a computer center in July 1967 when the University of Pennsylvania installed an IBM System 360 Model 40. The Model 40 was an interim machine which was replaced within six months by an IBM System 360 Model 65. In the second half of 1968, a three year grant for approximately one million dollars, was secured from the National Science Foundation to fund non-sponsored research and to establish a regional computing facility. The grant and the resultant increase in demand for computing services brought about enhancements to the 360/65 configuration. In December 1968, the Model 65 was upgraded to a Model 75.

At the conclusion of the grant period, the pessimistic prospects for its renewal prompted the University of Pennsylvania to seek an alternate organizational structure to ensure the technical growth and financial viability of their computer services operation. Essential to this new approach was the expansion of usage to offset the costs of a larger computer facility with its associated lower per unit costs. The majority of the increased usage was projected to come from other academic and medical institutions with limited dollar revenues anticipated from 'for profit' scientific organizations. The university realized that the participation of other area institutions was contingent on establishment of an independent central agency like a consortium.

The University City Science Center, a not-for-profit corporation, was created in the mid-1960's to provide a mechanism for effective application of scientific and technical knowledge. This corporation possessed the supportive organizational structure necessary to the success of the consortium approach which was viewed as the solution to the University's computing dilemma. The Science Center shareholders, twenty-six universities, colleges and medical schools in the Delaware Valley, were all represented on the Board of Directors. Also represented on the Board were prominent leaders from business, industry, and government communities.

The decision by the University of Pennsylvania to transform their computing center into the UNI-COLL Corporation, a wholly owned, not-for-profit subsidiary of the Science Center, was based upon commitments from the presidents of the University of Pennsylvania, Drexel University, and Bryn Mawr College, and the intent of other institutions to participate in the shared facility. These presidential decisions followed planning sessions involving computer center directors and faculty users on the Pennsylvania, Drexel and Bryn Mawr campuses.

Once the decision on organizational structure was reached, the hardware configuration was evaluated. The results of the evaluation indicated that the 360/75, which had grown to a near maximum configuration, would not be capable of handling the increased work load that the new organization would generate. Consequently, in the summer of 1972, the 360/75 was replaced by a 370/165.

## CURRENT CONFIGURATION AND SERVICES

One year later, in the summer of 1973, the 370/165 was superseded by a 370/168. This system, with three million bytes of memory, is currently operating under OS/VS2 Release 1.6. The processor is supported by a fixed-head file (drum), 3.6 billion bytes of online disk storage, six disk setup devices, and six tape drives. The 370/168 services forty-six remote job entry (RJE) stations; twenty-two are dedicated ports and the remaining twenty-four share six dial-up ports. System throughput averages 4,000 jobs a day of which approximately 1,000 are batch monitor jobs. In addition to comprehensive batch services, the 370/168 provides interactive services through locally enhanced versions of TSO and APL/SV.

In January 1974, a Digital Equipment Corporation System KI10 was added to the complement of services available from UNI-COLL. The DEC10 facility, which UNI-COLL operates in the Wharton School of the University of Pennsylvania, was purchased to augment time-sharing services. This system, currently being prepared for production, will provide time-sharing services with emphasis on the FORTRAN, BASIC, and APL languages. The combined services of the 370/168 and KI10 systems provide UNI-COLL with one of the finest complements of hardware and software available from a single vendor of educational services.

## EFFECTIVE INTERACTIONS

The UNI-COLL Corporation has adopted a clearly defined posture on the organization of computing services through the three years of experience gained in providing computing resources to the fifteen universities and colleges and the several hundred low volume non-academic customers that form the customer base. Effective customer interaction is basic to a successful working relationship. UNI-COLL addresses this need through three distinct devices:

- An approach to the delivery of computing services that establishes a boundry between the responsibilities of UNI-COLL and the customer;
- A customer mechanism for addressing administrative procedures, ensuring responsible and efficient use of computing resources, and monitoring supplier performance; and

- A broad based committee structure that ensures feedback to the supplier from users at all levels of the cutomer's organization.

## ESTABLISHMENT OF BOUNDARIES

UNI-COLL addresses problems within a clearly defined context of problem definition and solution analysis, design, implementation and evaluation. The success of the approach is predicated upon an evaluation at each stage to ensure that objectives have been met before proceeding to the next phase of problem solving.

Identification of the participants in the problem solving process and their interactions, is an issue of paramount importance. The computer service delivery mechanism is viewed by UNI-COLL as a continuum with four discernable areas of responsibility: hardware operations/systems support; applied technical support; applications services; and the end user.

Hardware operations/system support is a reliable, responsive, production oriented resource that is available on demand and functions until the tasks to which it has been assigned are completed. This resource, which is operated by trained and experienced systems operators, maintained through a rigorous program of preventive maintenance and testing developed in concert with the manufacturers, and supported by a professional, experienced staff of systems programmers, represents the heart of the computing utility.

Applied technical support is an activity which guarantees the availability and proper functioning of the software tools essential to the solution of a broad range of applications programming problems. This activity encompasses the installation, testing, maintenance, and documentation of manufacturer and externally developed software as well as the internal development of software tools that address needs that are particular to the UNI-COLL customer base. In addition, applied technical support includes a staff of systems designers and program consultants who interface with the applications services staff and the end users of applications system.

The third activity, applications services, is charged with the primary responsibility for the implementation, maintenance and operation of applications systems. Problem definition, objective definition, alternative planning, solution analysis, and solution evaluation are components of the systems process which applications services addresses in conjunction with the applied technical support staff and the end user.

Typically, applications services is composed of senior analysts/programmers, programmers, and technical writers. The senior analyst/programmer functions as the systems designer, project leader, and the interface with the consumer of the service. Members of this group have as a guiding principle in their professional careers the desire to produce workable and satisfactory solutions to the problems of the customer.

The end users are consumers of applications systems and thereby encompasses almost all administrative and educational entities within the University. Although frequently not computer-oriented, they have pivotal roles in producing effective systems by bringing to the relationship a clear understanding of needs and objectives. In addition they must be willing to work with application analysts to assist in problem definition, objective definition, alternative planning, solution analysis and solution evaluation. Above all, the end users must view the entire mechanism as an extension of their capabilities and responsibilities.

Within this framework, UNI-COLL bounds relationships with its customers by assuming full responsibility for hardware operations/systems support and applied technical support. The duties of applications service and the end user are designated as customer functions. This structure is effective in both the academic and administrative areas. Typically, the researcher and student provide all of their own applications services and are, in almost all cases, the end user. On the administrative side, applications services is part of the customer's organization and control of the customer's sytems is maintained within that organization. The administrative data processing staff (analysts, programmers, production control personnel, and administrators) are free to concentrate on effective administrative applications rather than getting caught up in the day-to-day problems of running a computer center.

The above definition of boundaries in the customer/supplier relationship has an important result; UNI-COLL addresses its academic and administrative customers in the same way. Both types of customers require hardware operations/system support augmented by applied technical services. When the customer is otherwise unable to attain applications service, UNI-COLL will, on a time and materials basis, provide this service.

*Customer Organization.* An Office of Computing Activities is the mechanism by which the customer can address the administrative aspects of the customer/supplier relationship. It is the primary contact for UNI-COLL and provides the following essential services:

- Establishes and administers procedures for allocating computational resources;
- Provides utilization reports and analysis;
- Encourages efficient and responsible use of computing resources;
- Projects computing requirements including not only main frame usage, but also remote job entry and keyboard terminals requirements;
- Encourages both intra- and inter-university cooperation; and
- Monitors the performance of the supplier.

The responsibilities of the customer's Office of Computing Activities are complex, varied, and time-consuming. It is vital that this office be staffed by highly qualified personnel who are familiar with, and sensitive to, the computing needs of the administrative and academic users of the university.

*Exchanges of Experiences.* The final component in a successful customer/supplier relationship is the establishment of a mechanism to ensure feedback at all levels. Clearly, the customer's Office of Computing Activities is an integral part of such feedback. However, a complement of committees and user groups is also essential.

UNI-COLL established an Operating Policy Advisory Committee (OPAC) whose members are directors of university computing activities, faculty members, and directors of administrative data processing organizations. This group, meeting at least once every month, provides a forum for discussion of common goals, software packages, hardware changes, systems modifications, and administrative procedures. OPAC also provides a means by which the conflicting requirements of different member organizations can be resolved.

UNI-COLL advises that a University Computing Committee be created within the customer's organization. This group should be composed of: the Director of Computing Activities; faculty members from participating schools; and representatives of administrative data processing. The meeting should provide a forum for the discussion of issues related to campus computing. Resolutions by the committee should be used to guide the activities of the DCA and other university administrators.

A user group, which is chaired by the manager of Applied Technical Support, is another aspect of the UNI-COLL/Customer interface which ensures adequate feedback. If a user of UNI-COLL services does not feel his or her particular problems are being addressed through alternative committees, the user can take his/her suggestions, complaints, and problems directly to UNI-COLL management in the monthly user's meeting.

## CONCLUSION

It is evident from the historical events described that UNI-COLL was formed out of economic necessity in an effort to maintain an excellence in computing services. That goal is being achieved.

Fortunately, the three years 1971-1974 have been a period of continued growth for UNI-COLL. The customer/supplier relationship that has evolved is extremely sensitive to the responsibilities of service, and the computing services delivered by UNI-COLL have been determined through an exposure to the requirements of a multi-user community. As a result, common service denominators are automatically sought, formalized, and reapplied.

The evolution of UNI-COLL as a phenomenon may well become wide spread as the economies of computing continue to favor the large, general purpose installation, an economic reality beyond the scope of the individual academic institution.

# UNI-COLL/Penn Relationship: The Penn View

**by Jon C. Strauss**

The justification for, and the early history of, the UNI-COLL/PENN relationship has been well documented by J.C. Emery, former Director of Computing Activities at the University of Pennsylvania.[1] The companion article in this proceedings by Wm. Knapp describes the current UNI-COLL/PENN relationship as seen from the UNI-COLL viewpoint. This article briefly reviews the current situation from the viewpoint of the new Director of Computing Activities at the University of Pennsylvania. The primary emphasis is on presenting a candid appraisal of the problems and successes of this rather unique relationship of a separate private corporation providing vital computing services to a large private university. Recommendations are made for others considering similar future courses of action.

## STRUCTURE

PENN views UNI-COLL as a supplier of IBM 370/168 services and as a facilities manager of the Wharton School DEC-10. The interface between Penn and UNI-COLL is managed by the Office of Computing Activities (OCA) at the University of Pennsylvania which provides coordination, internal accounting, terminal management, specialized user services, and centralized planning. Currently Penn has budgeted $1.25 million for 370/168 services for academic, administrative, and sponsored research. The relative usage of these three areas is approximately 45% academic, 35% administrative, and 20% sponsored research. Directly related is the approximately $450,000 that PENN spends on terminals and supplies and $100,000 to maintain the OCA. The Wharton School contracts directly with UNI-COLL to manage a DEC-10 system. In addition, there are many specialized use computer systems on campus ranging in size from an IBM 360/65, a DEC-10, and a UNIVAC 70/46 to PDP-8's and other minicomputers.

## MOTIVATION

The historical motivation for the UNI-COLL/PENN relationship has three major components: technical, financial, and political. Technically, by setting up a single corporation serving many of the educational institutions in the Delaware Valley, founding institutions hoped to realize large economies of scale. Financially, it was envisioned that a separate corporation would facilitate limiting the large budget deficits characteristic of the previous Penn computer center. Politically, by playing a major role in the organization of UNI-COLL, Penn was being a good citizen of the Delaware Valley higher education community.

Although the UNI-COLL/Penn relationship is a demonstrated success, these three motivational factors require hindsight comment. While economies of scale are an often quoted technical justification for centralized computing, they do require heavy equipment utilization which can be a problem in the fluctuating demand environment of higher education. Another factor working against economy of scale is the economy of specialization made possible by tailoring configurations (both equipment and personnel) to the application. Increased availability of low priced minicomputers, specialized software, cost effective used equipment and increased user awareness, competence, and confidence are deemphasizing the importance of economies of scale.

While the separate corporate structures of Penn and UNI-COLL theoretically provide lower financial liability for computing to Penn, in actuality Penn is dependent on UNI-COLL and therefore must be financially supportive. As UNI-COLL's financial strength has increased this situation has improved almost to the point originally envisioned.

From a political viewpoint, it is probably not surprising that often political issues have tended to dominate good technical and financial judgement in the UNI-COLL/Penn relationship.

## CURRENT ISSUES AND PROBLEMS

For technical, financial, and political reasons, Penn has an institutional commitment to support UNI-COLL. At the same time, Penn is moving towards full responsibility center budgeting and accounting where individual responsibility centers, such as schools, have profit and loss responsibility. For centralized computing, as for any central services in a decentralized decision environment, institutional commitment to the centralized service and decentralized financial decisions are not compatible. The currently available economies of specialization in computing are exacerbating this problem. Controls are necessary, but difficult to administer.

One of the consequences of moving to a true cost incremental computing charging scheme for services purchases from UNI-COLL, has been the inability to take advantage of marginal costing for new development. While this is certainly an advantage where it forces detailed *a priori* cost analysis and justification, it can be a problem on a day to day operational basis.

## SUCCESSES

The fact that two years later in 1974, UNI-COLL exists and is financially solvent is quite a success in itself. However, there are also some tangible successes from the Penn viewpoint.

First, true incremental cost computing has been achieved. Because each computing project must be justified on its own merits, the old marginal costing syndrome is prevented where many things that don't cost much more individually are obtained, but in aggregate they force acquisition of new equipment.

Second, differential pricing and responsibility accounting for each shift has balance shift usage and substantially increased the computing obtained for given dollars.

Third, future growth of the UNI-COLL load promises to reduce unit cost and make possible the expenditure of a larger percentage of Penn's computing dollars for distributed computing.

## RECOMMENDATIONS

Much has been learned in the process of establishing the currently successful UNI-COLL/Penn relationship. Unfortunately most of the lessons sound obvious and trite. Several points are repeated here:

- Planning is the key ingredient.
- Objectives must be understood, enunciated, and tested before a formal relationship is consumated.
- Mechanisms (technical and contractual) must be established and periodically tuned to achieve the objectives.

## CONCLUSIONS

The Penn computing community has paid a large price for the startup years of UNI-COLL both in terms of dollars, energy, and lost opportunity. This price has been paid however, and the current UNI-COLL/Penn relationship exists and works. With the increased financial stability of UNI-COLL and the increased awareness of computing needs of Penn, the computing community anticipates an evolving structure allowing a dynamic balance between the attractive features of both centralized and distributed computing.

## REFERENCE

1. *Networks for research and education: sharing computer and information resources nationwide,* MIT Press, Cambridge, Mass., 1974, Chapter 20.

# Chapter 8

# Libraries, Data Bases, Computers and LRC's: Are They Converging?

## Fee-for-service Data Center

by Daniel U. Wilde

The New England Research Application Center (NERAC) was established at the University of Connecticut in 1966 as part of NASA's Technology Utilization Program.* The purpose of NERAC is to help organizations in the Northeast, such as business and industry, colleges and universities, and state and local governments benefit by using someone else's technology. In other words, NERAC staff take technology that was invented in organization A and help put it to work in organization B.

Located at the University of Connecticut in Storrs, Connecticut, NERAC operates as part of the School of Business Administration, but has close working relationships with the School of Engineering and the University Library. NERAC's offices are located near the main University campus and its staff consists of 15 full-time employees plus many part-time undergraduate and graduate students. In order to better serve the high concentration of industry on the East Coast, full-time employees also live and work in Boston, New York City, and Philadelphia.

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*This research was sponsored in part by the National Aeronautics and Space Administration Contract NASw-2516.

## STRUCTURE AND FUNCTION OF NERAC

Historically, NERAC has received funding from two sources. First, NERAC receives funds directly from NASA. In 1974, this will amount to $225,000 or about 55% of the total budget. Second, NERAC charges its clients for the services they receive. In 1974, client income is expected to be between $190,000 and $200,000 or approximately 40 to 45% of total income. Charging only for the value added by service, NERAC does not attempt to recover any of the costs of the original research. Nevertheless, the fact that NERAC is partially funded by NASA and that it must generate the remainder of income by selling capabilities to users has affected how the service has organized to accomplish goals and mission.

NERAC consists of four groups or divisions, each with specific operating goals: marketing; information; computer; and administration. The marketing division is responsible for convincing organizations that they can benefit from using NERAC and should therefore subscribe to the service. This is done via face-to-face sales presentations to key decision makers within individual firms. NERAC's sales activity is led by a marketing manager who is assisted by three full-time marketing representatives and a marketing coordinator. Since NERAC's dissemination region covers the Eastern United States from Maine to Washington, D.C., this area has been divided into four territories centered around Philadelphia, New York City, Connecticut, and Boston. The strategy is to hire full-time, very experienced salesmen who live in and are familiar with each territory which enables them to visit more prospects and clients with less travel time and expense. Finally, the marketing coordinator acts as the home office representative of the marketing division and oversees an aggressive client followup program to insure client satisfaction and to track technology transfers.

The information division is responsible for providing service to clients. This group consists of an information manager, two information specialists and an information coordinator. Here, the information manager assigns incoming requests to information specialists and suggests how they might best satisfy client needs. Usually, assignments are determined by the technical nature of each particular question. For example, if the client is interested in flameproofing polymers, his or her request would be assigned to an information specialist who has a PhD in Chemistry. Likewise, if a question is related to metallurgy or engineering, it is assigned to the information specialist who has a PhD in Physics. If no one on the staff feels completely competent to handle a particular question, NERAC is able to call upon members of the university faculty for help and guidance. This technical matching allows staff to dialogue each user in technical terms that s/he uses in his or her day to day work which also insures that

NERAC staff understand the client's request and can focus on his or her needs. Clients consistently praise this aspect of NERAC service. Finally, once answers have been found to a given question, the information coordinator assembles the material and prepares it for shipment to the client.

The computer division is responsible for operating NERAC's captive computer system. It is staffed by a computer manager who also acts as system programmer and chief operator. He is assisted by a number of part-time students who help operate the machine around the clock. By having a captive computer, NERAC is able to guarantee service to its fee paying clients. In other words, runs can be scheduled to meet the demands of clients and do not need to compete for computer time on some other machine. Furthermore, computer costs are fixed, and NERAC unit costs decrease as useage increases. This has proved to be the key factor in NERAC's approach to the marketplace.

Although the NASA data base is one of NERAC's important information sources, staff almost always augment it by searching other data files, such as: the National Technical Information Service (NTIS); the American Society for Metals (ASM); World Aluminum Abstracts (WAA); Chemical Abstracts Condensates (CA); and the Educational Resource Information Center (ERIC). When NERAC does not have the proper information on the captive computer, staff purchase it from other members of the NASA Regional Dissemination Center network or from other information services throughout the world. In some cases, the captive computer is used to help generate data bases. For example, NERAC helps the American Society for Metals produce the indexes to three journals (*Metals Abstracts, Alloys Index,* and *World Aluminum Abstracts*) and, as a byproduct, produce data tapes for shipment throughout the world.

Although NERAC has been in existence for eight years and must be considered operational, staff still are looking for better ways to encourage the transfer of technology. The center cannot provide the perfect answer to every question every time. Because NERAC does not have the resources, and sometimes because the technology has yet to be invented, the center cannot or does not find an answer to a client's particular question. However, staff can maximize the probability that a user will benefit from NERAC's service by permitting and encouraging him or her to use NERAC whwnever possible.

NERAC is greatly concerned that each of its clients benefit from the service. To insure that this happens, the center has a most vigorous follow-up program. Four to six weeks after the answer to a question has been mailed to a client, that client is called to insure that NERAC was responsive to that client's request. If by chance the response was inadequate, staff ask how NERAC can improve. Perhaps staff did not understand the question or the client misstated the need. In either case, NERAC personnel try again. On the other hand, if NERAC hit the mark, staff begin to watch for the transfer of technology. In addition, if a client does not have work in progress and also has not called in several weeks, NERAC staff call him to inquire how they might be of service which encourages the client to maximize his or her use of NERAC and increases the chance to satisfy him.

Finally, NERAC seeks to serve a wide variety of organizations. Fixed-cost, subscription packages plus a vigorous followup program has made it possible for the center to be very responsive to the needs of both large and small business. Since there are many small businesses in our region, staff pay special attention to insure that they are reaching these companies. To do this, NERAC has established a special program where marketing representatives call as many small business chief executives as possible to explain the program and offer them the opportunity to participate in it.

## INTERFACES WITH THE UNIVERSITY OF CONNECTICUT

It is most important that one appreciates that the NERAC budget must be balanced through our sales and service efforts. Any excess service capacity must be used to better satisfy clients in hopes that they will renew next year. Nevertheless, the center has tried to provide data bank services to the university.

The first approach to faculty members was on an individual basis. NERAC organized seminars by department and tried to sell them on the value of the product. Not only was the service new to them, but also staff discovered that individual faculty members and departments had no resources that they could allocate on their own. Some wanted to try the data center but had no funds. Opportunity costs were such that it was easier to sell in the industrial marketplace.

A second experiment was the bulk rate sale of data base searches to faculty members via the University Library. NERAC tried to give faculty members a cut-rate by permitting library personnel to design retrieval strategies for direct processing on NERAC's computer. The concept was great, but it did not work. Part-time strategy designers cannot know all the retrieval characteristics of the various data banks. In addition, no one person can understand all technical disciplines required to answer various questions. This is why NERAC hires full-time professionals with graduate degrees in a variety of fields. In fact, NERAC administrators have come to realize that it is this guidance that is the product, not information.

As part of the bulk rate approach, a few searches were offered to every department which meant covering anthropology to zoology. In many cases, a question could not be answered because there was no computerized information on the subject. Thus, a democratic allocation of searches was very ineffective. Search topics should have been restricted to those that matched available data sources.

During early. experiments, a false assumption was made that academic researchers were different from industrial users. Now NERAC is approaching colleges and universities on the same basis as industry which means providing complete service all the way from telephone dialogues of user's requests to xeroxing article abstracts and obtaining documents. Preliminary results indicate that this approach has solved eealier problems.

Although computerized data banks are similar to libraries in that they contain useful information, there is one distinct difference: a computer tape cannot be browsed like a library stack. To retrieve computerized information requires an expensive system. In a library the user helps finance service by giving time and energy. For a computerized data bank, someone has to pay for data files, computer time, systems programming, and so on.

The costs of data bank retrieval can be significant. For example, many data base suppliers charge from $2,500 to $8,500 per year for files which means that a single backfile can cost from $15,000 to $40,000, and one might want to have at least five files. Computer equipment is expensive. For example, one commercial, on-line service is known to be spending $8,000 per month just for disk storage of five years of Chemical Abstracts. Think what the complete storage of many files would cost!

Finally, NERAC experience indicates that it is best to hire PhD's or MS's in various technical fields and then train them in relatively simple retrieval techniques. This has proved to be much better than taking someone with library experience and then having them try to learn Chemistry or Physics on the job. Of course, this kind of talent requries higher salaries, but paying clients believe it is worth the cost.

Although NERAC has components that are similar to other university functions, it has been necessary to organize it as a separate unit in order to achieve its mission. NERAC has hired its own reference staff because its users demand high level technical guidance. NERAC has its own computer so that it has priority service around the clock, seven days a week, 52 weeks a year. In other words, NERAC has a unique environment and has had to be structured to meet these conditions.

# Start at the Beginning!

### by John R. Merrill

The question is "Libraries, data bases, computers and learning resource centers: Are they converging?" The answer is, "Yes, in some places," and "about as rapidly as one might expect." Florida State University has a number of learning resource centers all over the campus. The main and largest resource center is in the main library; it serves about 5000 students a month. Along with other audio-visual hardware, computer terminals in learning resource centers on campus serve about 5000 students counting CMI activities alone.

The development of learning resource centers in libraries and elsewhere really comes in response to materials already developed, rather than before the materials are present for use. After pointing out the two most important problems in developing materials, this paper will present Florida State University's system as a useful model which is working well.

## BIAS

It's only fair to expose one's biases from the start. First of all, I believe there exists no one way to teach well. In fact there probably exists no one correct way to teach one group of students one piece of material at any one time. Second, the choice of medium for the presentation of material should be made on the basis of what is being learned by the students. Media include: lecture; group discussion; one-to-one tutorial sessions between students and instructor; text book; lab; programmed text material; slides; slide-tapes; instructional television; the computer as a calculator; and tutorial CAI. The choice among them should be made on the basis of the material presented.

Education can no longer afford to replace machines with people. Historically colleges have been asking the instructional staff in courses to do things which machines can now do at least as well and sometimes better. Because people have been used to doing things they now don't have to do, people have not been able to do many of the things that only people can do. I believe educaton must use people correctly.

## MEDIA CHOICE

As a medium in Florida State experience, the lecture tends to be good for summary, correlative (forest for the tree), and exposure kinds of material. Certainly the lecture serves some needs for some instructors, and also seems to fulfill model figure needs for some students. The lecture is also very cost effective in the narrowest sense of the word. If one brings together 4000 people and sits them down in front of 1 lowly-paid instructor for three one hour periods each week, one has a mightly low per student hour cost.

On the other hand, lectures are not good for experience with formulas or vocabulary, and language departments have been moving towards either highly interactive discussion type language sessions or towards the language laboratory concept. Because lectures are a particularly passive situation for the student, they are not good for active student learning. Finally, lectures are not good for working out individual student problems.

Tutorial computer assisted instruction tends to be quite good for highly interactive, student determined learning, but is not particularly good to replace a programmed text. In fact much of the difficulty that educators have experienced with tutorial CAI has been encountered when CAI has replaced programmed text manuals.

The contention of this paper is: 1) education is going into bad times; 2) The full range of media must be made available to teachers so that content can determine the medium chosen; 3) Assistance must be made available for faculty restructuring of instructional process; and 4) With materials in hand, learning resource centers, in libraries and out, will follow quickly.

## PROBLEMS

There are two fundamental problems. First, university structures are needed to ensure media will be used. Learning resource centers will need finally to be fully available to instructional staff. Second, groups need to be made available to the faculty whose main charge is to help faculty do new things.

The second fundamental problem is faculty incentives. Instructional development work, the full use of all media, time spent to reformat courses, and so forth, should all count in every evaluation of every faculty member; evaluations of an annual nature and certainly evaluations for promotion and tenure. Funding sources must also make money available to faculty to support the production of materials in various media. When an instructor embarks on an instructional development project, it should appear to the department to be a no-direct-cost situation.

## FLORIDA STATE UNIVERSITY'S ARRANGEMENTS

Florida State University provides some administrative structures and support for educational development. First, there is a sincere commitment from the administration of Florida State towards instructional development in university courses. Instructional development work on this campus is mentioned prominently in the State of the University Addresses that President J. Stanley Marshall gives each year. The president has also been very helpful in working out the financial package which will bring PLATO to Florida State University in the Fall of 1974. These are examples of the many ways the central administration demonstrates commitment from the very top towards instructional development work.

Secondly, Florida State has a unit known as the Division of Instructional Research and Service which is a faculty and staff group with the specific charge to help faculty all over the university improve instruction. The Division of Instructional Research and Service is made up of three parts. An Instructional Media Center oversees the production of audio-visual material, the installation, repair, and service of audio-visual equipment, and the learning resource centers around the campus. A second group in the Division of Instructional Research and Service, the Office of Evaluation Services, is the large testing service for the campus. Services include exemption exams, standardized exams, student evaluations of instructors (at Florida State, every instructor is evaluated by his students every quarter), and so forth. The Office of Evaluation Services also works with the Center for Educational Design on computer generated testing. The Center for Educational Design is made up of faculty, graduate students, programmers, secretaries and undergraduate assistants whose job is to help faculty in the various disciplines design and implement new ways of teaching their courses or curricula. All three sections of the Division of Instructional Research and Service taken together facilitate changes in education at Florida State University.

To address the issue of faculty incentives, the Division of Instructional Research and Service administers the Council for Instruction Awards which is a faculty committee charged with overseeing instructional development on campus. There are two competitive awards programs.

First, there is a summer grants program. Each summer, 12-15 content faculty from all over the university are awarded grants on a competitive basis to spend the summer with resources made available to them to restructure their course content. The second awards program is an academic year award program which doesn't include faculty salary money but does fund all the support necessary to restructure full curricula. Receiving either or both of these awards is increasingly important to faculty. The winning of such an award is awarded in recognition throughout the university.

Secondly, the Division of Instructional Research and Service advises faculty committees and the central administration on policies concerning instructional procedures, instructional incentives, means for evaluation of instruction, needs for learning resource centers, and so forth. The results have been clear: a recent memo from the Vice President for Academic Affairs explicitly states that instructional development should count as heavily as research towards promotion and tenure. Instructional development will soon be counted in annual evaluations of every faculty member at Florida State University and may be counted in the 12-hour law forms made out each quarter for each faculty member throughout the state university system.

In conclusion, Florida State University is set up to: help faculty improve instruction; to make available all media; and to deal with incentive issue.

# Convergence of Information Technologies

by Thomas J. Karwin

Hardware technologies, computing and communications technologies, have been coming together for some time. Such convergence is illustrated by the time line chart on this subject which was developed by the Conference Board .[1]

However three other aspects of convergence may also be occurring in colleges and universities. Because I am most familiar with learning resources centers, much of this paper will emphasize the changing relationships between learning resources and computers in instructional applications.

## STAGES OF CONVERGENCE

Conceptual convergence is a primary stage preceding action. Starting with perception of the generic relationships among the information technologies, and of the possibility of using these technologies in various combinations for instructional purposes, conceptual convergence has already occurred in many quarters. It may be followed by studies of the advantages and disadvantages of combining technologies, and, perhaps, by a commitment actually to create some combination. Procedural convergence is the process of actually combining or correlating information technologies toward some single purpose. Structural convergence which occurs last refers to changes in the organizational relationships among computer centers, libraries, learning resource centers and data bases. Each of these three apsects of convergence (conceptual, procedural and structural) can occur at different degrees of intensity. The current status of convergence on the Santa Cruz campus of the University of California is a case study of structural convergence which also illustrates aspects of conceptual and procedural convergence.

## A CASE STUDY

Conceptual convergence is most clearly evident among computing specialists, authors of instructional programming, and library systems analysts. Few learning resources specialists show much interest in more than the most straightforward combinations of media and computer technologies.

Perhaps because the definition is rather limiting, procedural convergence of media and computer technologies is rather uncommon. According to the original definition uses of graphic terminals constitute a convergence of hardware technologies more than of media and computers. There are a few instances of combining media and computer technologies, however. Some groups are making films from CRT displays. A fascinating project at the Santa Barbara campus combines slides, audiotapes and a minicomputer in the design of learning modules. Also at Santa Barbara, computer and television systems using a keyboard are combined in a teaching auditorium to allow instructors to display the output of interactive computing.

Most instructional uses of computers at the Santa Cruz campus are "Problem-Solving I" uses, to use Gerry Weeg's terminology (See Chapter 4) with few "Problem-Solving II" uses. Very few projects involve uses of media other than CRT's. Elsewhere within the University of California system no media-computer interfaces within U.C. are as sophisticated as, for example, the system at Golden West College which provides programs on nursing, art history and other subjects.

Libraries are another matter. There has been a great deal of study within the University of California of the benefits of automating various library functions, particularly book ordering, circulation and cataloging.[2] Some automated cataloging projects are already well-established. The Santa Cruz campus has been using MARC format cataloging of its print holdings for several years, and also has developed a unique computerized system for cataloging projection slides.[3]

Structural convergence is a crucial area. Certainly, the ultimate form of structural convergence occurs when the library, the computer center, and the learning resources center are placed under the same director. This has not occurred on any campus of the University of California, although there are persistent reports of conversations among these directors.

A search for less obvious forms of structural convergence may be more fruitful. Two forms suggest themselves: overlapping functions and physical proximity. Libraries and learning resources centers often have overlapping functions within the University of California like holdings of "non-print" media materials. Learning resources centers rarely have books in circulation, but libraries often provide photographic services and audio listening rooms. Similarly, libraries sometimes have computing capabilities, and invariably have computing specialists on the staff. In fact, the picture is less one of of convergence than of the libraries moving into the territories of computer center and learning resources centers.

There's some evidence of physical convergence, too. At the Santa Cruz campus a central facility, the Communications Building, houses the learning resources center, the computer center and the campus' telephone facilities. Because this building was designed for these occupants, the physical structure lends some coherence to the planned communications cable system for the campus. However, it has not lead to any convergence of organizational structures. The Santa Barbara campus has a new learning resource center under construction, on a site which is immediately adjacent to that campus' computer center. In this case, too, no structural convergence is intended. Although physical proximity in these two instances has no effect on today's uses of information technologies it may facilitate future convergence or interaction.

While there are signs of convergence, the university is still in a very early stage. Some factors can foster or delay this convergence within the University of California: 1) systematic planning for optimal uses of scarce resources; 2) increasing interest in new strategies of instruction, particularly those that involve careful combinations of media, matched to specified learning tasks; and 3) development of high-quality academic programs for the off-campus, part-time learner. Each of these factors stimulates comprehensive planning, and recognition of the need to integrate the things of learning.

It is interesting to note that these same factors also can delay structural convergence. Emphasis on systematic planning, for example, has encouraged a flurry of plans for system-wide integration or coordination of activities in several areas. The University Library Systems Development Program, already mentioned, involves substantial uses of computers, but includes no planning for organizational convergence of libraries and computer centers. The recent appointment of the University of California Computer Policy Board, and the creation of the position of Executive Director of Computing, similarly do not portend convergence of computer centers with libraries or learning resources centers. Finally, the University's Advisory Committee for Learning Resources is concerned more with the production and distribution of media packages, and the development of stronger capabilities, than with converging. Because planners in each of these areas are concerned first to get their houses in order, these demanding tasks preclude giving much attention to deliberate convergence.

Learning resources specialists may be least active in conceptual convergence because they have the particularly challenging task of preparing for future instructional uses of media technologies. While available projections, such as those in *The Fourth Revolution,*[4] suggest a greatly expanded role for media in instruction, many learning resources capabilities are organizationally incoherent, understaffed, and underfunded, even (believe it or not) in comparison to computer centers. Such problems, combined with the rapid development of media technologies, the steady increase of workloads, and the accelerating shift from group uses of learning resources to individual uses, keep the learning resources planners and specialists fully occupied. Little interest in other information technologies should be understood to reflect these other pressures, and not some lack of vision or awareness of the other technologies.

## TRENDS TOWARD CONVERGENCE

Some colleges and universities have built combinations of libraries, computer centers and learning resources centers, or have appointed a czar of information technologies. Since some institutions are taking the approach of structural convergence, one should ask whether this approach is desirable or inevitable, and, by extension, whether institutions must be counted as laggards if they do not combine these functions organizationally. While higher education should explore vigorously the interfaces of information technologies, there is no necessity to create new organizational structures. In fact, one may even choose to avoid such efforts to combine, simply because the staff skills, the equipment, the procedures, and the traditions of each of these areas are so different. Cross-training of specialists in several areas may be more productive than juggling organizational charts.

Some new initiatives are needed with regard to the current and prospective users of these technologies. As information technologies become more sophisticated, and as institutional capabilities become more extensive, one should be sensitive to the problems experienced by the instructor or researcher who is interested in tapping these resources. When even specialists have difficulty in keeping abreast of developments in one field, how can one expect the faculty member to command the potential of the several information technologies in addition to keeping abreast of new developments in instruction or research?

Clearly, a key role is emerging for the guide, or systems broker[5] who can aide the faculty member in discovering, locating, understanding and using the information technologies that are available, or that soon will be available. Universities do not have systems brokers, as yet, but it appears that they will have to invent them if the potentials of information technologies are to be realized.

Given such guides, the currently modest trend toward convergence should accelerate. Whether this will be caused by enlightenment, budgetary crunches, or both, one should look forward to both the challenges of making it work, and the opportunities for exciting new approaches to instructional uses of the information technologies.

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# PART III

## THE PRESIDENT'S PERCEPTION OF COMPUTING

# Chapter 9

## A Foreigner in Our Midst

**by Ronald W. Roskens**

In a speech at Alexandria University April 2, 1974, President Anwar Sadat of Egypt berated both the United States and the Soviet Union for having miscalculated both Egypt's value orientation and her military prowess. The prevailing American view prior to the October war, he said, was that Egypt and the Arab nations were a confused, inept lot. The Soviet Union, on the other hand, from whom Egypt and her allies were seeking aid, was insisting upon a peaceful rather than a military solution to the Middle East conflict.

President Sadat went on to say, and I quote "The Russians' computer calculations showed Egypt would be crazy to act because it would be doomed to destruction, but there is always something that escapes computers."[1]

Many of us in the college and university world find considerable empathy with that last phrase. But it would be gross oversimplification to criticize computers on that assumption alone. It seems to me important to remind ourselves that the technological equipment upon which this conference focuses attention remains subservient to man and will always be susceptible to allegations of omission and insensitivity. I say this with full recognition that Herman Kahn and others have suggested that by the year 2000 computers may equal or even surpass certain characteristically human capabilities. However, it is not my purpose to argue that thesis.

As a point of information, I have been associated, to some degree, with computer operations at four different universities. Three of these institutions operate separate computer centers, and the University of Nebraska at Omaha is one unit in a three-campus system which operates a centralized computer network. I do not presume to pose as a computer specialist or necessarily as a knowledgeable critic, but I do hold some firm views which may serve at least to ignite a fruitful exchange.

## COMPUTER ILLITERACY AND ALIENATION

No single force, with its myriad permutations, has had greater impact upon the style and operation of American colleges and universities in the last half century than computer technology, not even the ideological schisms which convulsed our students bodies in recent years.

When colleges and universities installed computer technology, the phenomena of vested interests and natural resistance to change was encountered at every institution. In retrospect, I am persuaded that university officers committed an egregious error in the early days by introducing this foreigner in our midst without pervasive attention to instruction in the new language. Even today institutions of higher education are suffering the consequences of a fairly high degree of computer illiteracy.

Reflect for a moment upon the familiar academic scene. Many persons in an academic community are quite naturally antipathetic to such techniques as systems analysis, programming and budgeting systems, impersonality of mechanization, and the concomitant necessity to frame long-range goals. One is cognizant, on the other hand, of the reality of politics and diminishing resources which in combination have cast a piercing eye at the management style that has characterized college and university operations and thus forced immediate attention to short-range goals.

In many instances, of course, response to external pressures was not only reluctant, but resentful, and in some instances openly defiant. However, the point has now been reached at which the general public is again willing to consider university officers to be worthy of the task of managing the enterprise. Indeed, if they are regaining that public trust, it is essential that they frame qualitative judgments with institutions on the basis of refined criteria and valid data.

It is important to disabuse internal academic communities of the belief that there is a foreigner in our midst, and attend to the need for wider understanding of the computer and its contributions. At the University of Nebraska at Omaha, a poll taken now would reveal a large percentage of uncomplimentary views toward the computer center. This is certainly not the fault of the computer, nor necessarily those who operate it, or who administer the institution. It is rather a condition for which all share responsibility in that all have permitted alienation to prosper. Furthermore, fallout from this mentality has contributed to a general sense of mistrust of the university administration. Most people on the campus, of course, attribute the snafus, inaccuracies, and the inevitable downtime to incompetence of computer personnel. One usually begins such criticism by reciting the canon "garbage in – garbage out" and then proceeds to identify the machine and the operators as the culprits. There is little sense in reciting specific internal complaints. However, it is useful to underscore the presence of what appears to be a foreigner in our midst.

## INSTITUTIONAL PRIORITIES

Regarding the establishment of priorities and resource allocation, the University of Nebraska at Omaha is a living illustration of what Leuhrmann and Nevison[2] recently termed "the long standing controversy, both within and among universities, regarding the proper method of allocating the computer resources to the academic community". The extremes of the argument are legion. At one end of the continuum, computer time is available on a fee-for-service basis, and at the opposite end, as Luehrmann and Nevison[3] wrote "computing is regarded as a good that is *priceless*, in the technical sense that economists use the word – a good whose subjective worth is extremely difficult for an individual consumer to estimate in advance". The response of UNO to this dilemma is by no means a formidable model, but the institution is functioning much more comfortably and compatibly than was the case even a few months ago.

The genesis of the problem at UNO was the competition between local and university system requirements. First there were the mandated management factors of uniform payroll and accounting systems, and the like. Then there were individual institution requests for demographic data, special projects, and other items related to the local scene. Simultaneously, of course, there were increasing pressures for faculty research time and accelerated use for instructional purposes. The computer staff was at best, minimal in size but certainly dedicated and persevering. Inordinate complications arose when additional assignments such as the immediate development of an Affirmative Action Personnel Bank were imposed by the System administration.

The administration finally concluded collectively that although the university had sufficient hardware they were expecting far too much of present personnel, and the superimposition of additional assignments added insomnia and nausea to existing frustrations. Thus, a high level council has been established to deal with priorities at the University System level. At the campus levels and particularly now at Omaha there is a Users Committee which determines local priorities. These are workable steps, but not necessarily long-range solutions.

What are the priorities? The preferred model would permit, in first priority, free and immediate access to the computer for research and instructional purposes as is the case with the library. Information retrieval and data processing, although of considerable importance, would assume a position of slightly less significance. To the extent that these priorities were achieved would be sustaining and enhancing the primary mission of our respective institutions.

However I do not anticipate living long enough to witness the development of that scheme of priorities in most institutions. Frankly, the demands for management information which compound almost daily on the basis of requests from Federal and State agencies, and, indeed, internal users, make it eminently clear that data processing for management purposes is the number one priority. Of course, institutions must steadfastly assure access to computers for research and instructional purposes. But, the whole cost analysis and accountability syndrome has established MIS as a first priority for colleges and universities.

## RECOMMENDATIONS

Thus far I have referred to the foreigner in our midst, applying the term both to the computer man and machine. Three specific pragmatic recommendations, if implemented, would contribute to a redesignation as ally rather than foreigner.

*Exaggerated claims syndrome.* Often, computer personnel especially at the management level, give an impression that no task humanly conceived, however complicated, can exceed the capabilities of the computer or the personnel who operate it. As President Sadat said, "there is always something that escapes computers." Qualitative value judgments are a case in point. Examples, of course, are numerous, but computer personnel must emphasize care and explicitness in describing the parameters of machine and human capability.

*Instant gratification complex.* Time and again one is aware of circumstances in which consumers whose requests were probably framed late in the first place were told, by computer managers, that the results would be available by noon tomorrow, or three o'clock at the latest, or some other finite period. In many such circumstances computer personnel are attempting more to gain ego gratification through a "good guy" image and expedient movement of the consumer from the office setting, than to recognize the realities of available staff and hardware.

*Esoteric jargon habit.* This problem which manifests itself in many ways is troublesome because one is unsure of the basic motive. It could result from the natural reinforcement of communicating with persons who speak ones language; on the other hand, it may in some cases be a deliberate attempt to confuse the uninitiated as some parents or grandparents used to do by resorting to a foreign tongue. The following description is somewhat illustrative:

> "A programmer is one who passes himself off as an exacting expert on the basis of being able to turn out, after innumerable debugging sessions, an infinite series of incomprehensible answers calculated with micrometric precision from vague assumptions based on debatable figures taken from inconclusive documents of problematical accuracy by persons of dubious reliability and questionable mentality for the purpose of annoying and confounding a hopelessly defenseless department that was unfortunate enough to have asked for the information in the first place."[4]

Many who try to read the complicated newsletters of computer professionals come quickly to the conclusion that fortran is indeed a foreign language.

Surely it is time to eliminate the notion of a foreigner in our midst. Surely it is time to begin speaking a common language.

In my view one can expect marked improvements in the relationships between university personnel and computer professionals, if all face squarely their limitations. There are many preferences for a college or university chief executive model. With respect to computer center directors and their associates, however, this observer prefers them to be tough minded, fair, accessible, candid, eloquent managers. They should be regarded as equals among equals who understand and appreciate the mission of colleges and universities and who speak vigorously and forcefully about the role of the computer and computer personnel in our contemporary institutions.

Frankly, no one is too old to learn.

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# Chapter 10

## Evaluating Computing Services

### How Do You Evaluate the Computer Services Delivered?

**by Gary A. Wicklund**

At a time when education institutions are tightening their purse strings and finding student enrollments plateauing, the question of the adequacy of computing must be asked and computer services must be examined. Some comments about computing at the University of Iowa will provide background information for this discussion.

#### UNIVERSITY OF IOWA COMPUTING

At the University of Iowa there are three large separate computer centers: University Computer Center; University Hospital System; and Administrative Data Processing. The University Computer Center provides computing service for instruction and research at the university, including support of four Hewlett-Packard 2000 F minicomputers in addition to the central IBM 360/65. Also, there are several decentralized computer systems on campus maintained by departments for research and instruction in physics, engineering, medicine, and so on. The University Hospital System is an IBM 370/155 computer used for patient records and scheduling services. Although the system is designed for the processes which are implemented at the University Hospital, there has been some research on this sytem as the size of the data base expands.

In the Administrative Data Processing Department, an IBM 370/145 is used by the University for accounting functions, payroll, class schedules, grade reports, and so on. Each of the centers receive budgets from the state appropriations to the University of Iowa.

In order to use the University Computer Center, faculty and students must obtain a project number from their department or college allocation from the Graduate College for computer services from the University Computer Center. The center provides several kinds of services including processing time on the 360, custom programming, keypunching, storage, space rental on tape or disk and consulting.

The rates for computer time are determined by using the total annual expense budget of the University Computer Center and estimating the utilization of the hardware. The rates for different services on the computer are based upon the level of usage and the amount of income estimated for the year from that piece of computer hardware. By applying these rates, the sum of the incomes at the end of the year should be equal to the annual expense budget of the Center – the sum of the state appropriation, the research income, and other income. Consequently, revenue generated by the Center should be equal to the expenses of the Center. By having a budget and a rate structure it is possible to evaluate on campus computer services with alternative sources of computer services. For example, sponsored research may weigh the cost of computing services at the University Computer Center with outside computer sources. However, for a faculty member with unsponsored research or for classroom instruction, the alternative sources for providing computing are not available. Because the faculty member does not usually have funds to spend elsewhere, s/he is not able to make an evaluation of the computing received for the dollars spent.

Another way for the faculty member to evaluate the computer services for instructional or research needs is to look at the topics considered under the heading of user services. User needs vary from user to user, but some are similar:

- *Turnaround time:* can a maximum (minimum) time for processing jobs be established?
- *Reliability:* can known jobs and small students jobs be run on schedule with predictability?
- *Service:* can the user obtain the appropriate level of service from a central computer center staff?
- *Computer time:* can the job be processed faster on another computer?
- *Interaction:* can the user interact with the system during execution?

There are other characteristics which may describe a user's needs, but this list gives some indication of the difficulty of trying to measure what is adequate. For example, turnaround time of one day or more may be adequate for the user who is processing data for research, but the student developing a program who has to wait a day or more easily becomes discouraged. Before one can use turnaround time as a measure of computer services, it is necessary to classify the users. This is a particularly difficult task when looking at the cross section of users on a university campus.

Some of the items which fall in the same category with turnaround are: software support; hardware availability; programming assistance; and user consulting service. Since these are dependant upon the type of user, it is difficult to determine a level of adequacy.

The number of dollars spent for student computing provides a good argument for someone to increase computing power when expense per student is less than some average figure. However, it does not evaluate the type of computing service available to the student because of the variation of computing needs between disciplines as well as between users.

## SUMMARY

It is difficult, if not impossible, to evaluate computing services because of the diversity of users on a university campus. However, some questions may indicate possible areas of beginning for an evaluation of computer services, and illustrate why it will be difficult to evaluate computer services.

- Can a central facility be evaluated by comparing its performance with its stated claims? Is the central facility doing what it claims it can do? Evaluation by comparison may permit the user to document his ability to get a job processed on schedule.
- Can computing services be evaluated by classifying types of users? Are users in a particular class getting their computing done?
- Can computing services be evaluated by the charging policies? Would free computing to users permit evaluation to be made by the results rather than by the cost of a job?
- Can evaluation take place on computing when there is decentralization and widespread use of minicomputers? As decentralization increases, the evaluation is more difficult because of the convenience of terminals.
- How can one evaluate batch versus interactive computing for education? Research?

Because of the complexity of evaluating computer services for users on a one university campus, it is difficult to establish a model (or standards) which could be used by any university to determine if computing is adequate. Evaluation has to begin with the definition of the needs of the users and progress to a comparison of these needs with measures of the equipment and how well it is being utilized.

# How Do You Evaluate the Computer Services Delivered?

**by Jean Allard**

"How do you evaluate the computer services delivered?" From a technical point of view I think I should answer the question posed by this panel by saying "I don't." In the chain of command at The University of Chicago the management of computer services is not within my jurisdiction as the Vice President for Business and Finance, but instead is supervised by a Board of Computing Activities and Services. This Board includes both faculty and administrative staff, and includes the University's Comptroller who reports through my office. The Director of the Computation Center reports to a colleague, the Vice President for Programs and Projects whose office, among other things, provides centralized services for government grants and contracts. However, I do evaluate computer services delivered for several reasons.

First, The University of Chicago has a very closely-knit management. Vice Presidents share almost daily a proliferation of management problems, including computer services, with colleague Vice Presidents, the Chaairman of the Board of Computing Activities, and the Director of the Computation Center, whose operations are supported by the Business and Finance staff and who, at his own initiative, has joined as a regular participant in the weekly Business and Finance staff meetings.

Secondly, at The University of Chicago, the Computation Center is a centralized activity providing computer-related services on a cost-recovery fee basis. Its services are provided for research, instruction and administration. The income of the Center, whether from grants and contracts or from the University's general budget, is at the discretion of the user, and there are competing demands for the allocation of these dollars. While the University community is in many ways a constrained marketplace, the faculty is an independent group and there are alternatives to the use of the Center's services and these alternatives are from time to time used. Thus the Center and its services are evaluated, and it is expected to offer a broad range of services on a competitive basis. In these days of fiscal exactitude this means services which are reasonably comparable to other alternatives and which may be offered at lower marginal costs. Since cost recovery is a basic operating policy of the Center and since the University has rejected the concept of free access, by definition the Vice President for Business and Finance does evaluate the computer services delivered.

How does one commence the evaluation process? Initially there are basic concepts at stake, that is, if there remains any choice, what is it the institution wants, or perhaps what is it that the institution has to have, by way of computing services. But for the fact that The University of Chicago places extreme importance on its role as a major research as well as a teaching institution, one might be tempted to evaluate computer services in much the same way that one evaluates a public utility. Are the services desired performed at the cheapest price? In a world of no monopoly but rational decision making, computer services are like electricity. One buys at the cheapest price for the level of service demanded. In fact, price at this level of evaluation is a factor.

Probably more important, however, is measuring the computer and computing services as an intellectual resource. One asks questions and makes appraisals here much in the same way one approaches the institution's library. Clearly this test of capability is at the core of the University's recent decision to install an IBM 370/168. This was probably also true at times when the institution commenced use of an IBM 7090, the 7094 coupled with a 7040, and successively through the 360/50 and 360/65.

A third mode of assessment is to consider one's computer and its capability as an experimental instrument in its own right. This was a determining factor in setting up a Computation Center at The University of Chicago, a fact documented by the absence of any professional management of the Center until quite recently. For many years the Center was managed exclusively by part-time faculty and essentially with little service orientation. Rightly or wrongly, the continued provision of services at the University is currently almost without any but nominal interest in evaluation and use of the computer as such an experimental instrument.

At The University of Chicago, evaluation is set then in the context of the price-availability utility measure and as an intellectual resource.

However, once these determining factors have been set, evaluation continues in the competitive setting.

At any research-oriented campus there is a terrific drive on the part of investigators to "have one of my very own," the ongoing dilemma of central services versus multiple discrete computer operations. The University of Chicago faculty is no exception, and there are, even for a small, single-campus institution, a considerable number of laboratory minicomputers about the campus (probably more than 50) and several divisional computer facilities. The Center's management believes that appropriate use of small computers for laboratory equipment control and data acquisition would not conflict with the Center's services. Integrating and interfacing minicomputers with the Center has and will continue to shift general purpose computation now done on these systems back to the Center. There is a commitment as well to centralized services by the Computing Activities Board. In a proposal to the Board for approval of purchase of a new computer, the investigator has a heavy burden to justify the necessity of an independent operation because the failure to share centralized costs places a heavier economic burden on University colleagues. The cost is high to the institution, which bears a heavy burden through its subsidy of non-grant reimbursement.

Of fascination from a competitive point of view is the free or nominal charge alternatives available to the academic component of the institution from the national science laboratories. Geophysicists not only are reimbursed a United Airlines ticket to the high altitude National Center for Atmospheric Research in Boulder, Colorado, but enjoy free computation, advice and other good things through that laboratory's facilities center. Even closer to home, University of Chicago faculty in high-energy physics and in chemistry work at low cost on Argonne National Laboratory-provided computer facilities and on hardware provided to the Argonne Laboratory at no cost by the Atomic Energy Commission. The same arrangment is available at Goddard Space Research Center, sponsored by NASA and NOAA, for faculty doing research in numerical techniques and mathematics, and there are numerous smaller decentralized centers.

The University also finds competing educational institutions whose facilities are used when an investigator participates in joint research with a colleague from another institution. University of Chicago staff measure the requirement of using University computation facilities against the location of the recipient of the grant, and against the spread of costs (10-15%) before computing work is allowed to go elsewhere. But what can one do with the British-trained Dean of a Division who enjoys free travel and accommodation in his federally-funded research, where the destination could actually be a computer at Oxford in England, where the British universities provide free computing services to their own.

The price of services from the 370/168 are set to meet as much of this competition as possible. There is real inducement to increase its use and volume over the next two years. It is hoped that many faculty will "get the habit" and that the decision to install and amortize this equipment over the next ten years will net out to be a wise one.

Nevertheless the burden on the computer experts and the Board of Computing Activities and the University's management is a tough one. There is no question the competition forces the need for intellectual and fiscal evaluation of demands for computing services that are needed and are wanted at home.

# Evaluation of Computer Services at UW-Madison

**by Richard R. Hughes**

Evaluation of computing is, indeed, a difficult task. This is especially true with the complex mixture of users and facilities typical of a large university. (See Figure 1) In addition to two campus-wide centers, one academic and one administrative, there are 15 auxiliary centers serving groups of customers, 5 remote-job-entry terminals to provide access to the main academic center for special groups, and over 40 other facilities identified with particular research or instructional projects. The centers, both campus-wide and auxiliary, have come about from planned growth of computing services. The other facilities have various origins, since the campus administration views computing equipment as one method of solving research and instructional problems, to be adopted wherever it is cost-effective.

Like other campuses, the University of Wisconsin at Madison has been through many reviews of these computing facilities to determine whether they are really providing the desired services efficiently. Full evaluation requires considering at least three major types of computing use.

*Administrative.* This service is largely based on campus overhead funds either directly or indirectly. Its evaluation requires intelligent appraisal of the value of the services by those charged with delivering the necessary end-services in the administration of the campus.

*Wide-use general access.* Computing has now become such a day-to-day activity that all students and staff should be provided with a minimal library type service without need for additional justification. At Madison,

**Figure 1. Computing Facilities at UW — Madison**

| | |
|---|---|
| **Campus-wide Centers** | |
| Academic Computing Center (MACC) | Univac 1110 |
| Administrative Data Processing | IBM/370/155 |
| **Auxiliary Centers** | |
| *Agricultural and Life Sciences* | |
| Computing Center* | Microdata/IBM 1620 |
| *Business* | |
| Data Processing Center* | IBM 1410 |
| *Education* | |
| R&D Center* | Datacraft 6024/5 |
| *Engineering* | |
| Engineering Computing Lab. (ECL)* | Datacraft 6024/3 |
| Data Acquisition & Simulation Lab (DASL) | XDS 930/AD-256 |
| *Graduate School* | |
| Waisman Mental Retardation Center* | Datacraft 6024/5 |
| *Health Sciences* | |
| Clinical Laboratories | 2 PDP-12/Linc |
| Laboratory Computer Facility (LCF) | PDP-12/Linc's (2)<br>Datacraft 6024/5 |
| State Laboratory of Hygiene | PDP-12 |
| *Letters & Science* | |
| Dept. of Chemistry | IBM 7094 |
| Center for Demography & Ecology | IBM 370/135 |
| Geophysics Computer Facility | Datacraft 6024/3 |
| Dept. of Psychology* | Datacraft 6024/5 |
| Space Astronomy* | Mod Comp III |
| Depts. of Zoology & Botany | Datacraft 6024/5 |
| **MACC Terminals** | |
| *Data and Computation Center*** | Microdata |
| *Mathematics Research Center*** | Univac 9200 |
| *Physical Sciences Lab*** | IBM 1401/PDP-8 |
| *Dept. of Physics*** | Microdata |
| *Primate Research Center*** | Univac 9200 |
| **Other Facilities** | |
| *Education* | |
| Motor Behavior Laboratory | PDP-8 |
| State Testing Laboratory | NCS Sentry '70 |
| *Engineering* | |
| Electrical & Computer Engr. Dept. | 2 PDP-11's |
| Mechanical Engineering Dept. | PDP-8/14 |
| *Graduate School* | |
| Biotron | PDP-11 |
| Physical Sciences Lab. | PDP-12, PDP-8, IBM 1401 |

**Figure 1 cont'd**

*Health Sciences*

| | |
|---|---|
| Clinical Labs – Clinical Chem. Div. | Linc |
| Chemical Instrumentation Research | PDP-12 |
| Gynecology & Obstetrics | Linc |
| Medical Genetics | PDP-8 |
| Neurophysiology | Datacraft 6024/5; 2 Linc's |
| Physiology | Linc (from LCF) |
| Programmed Medicine | Linc |
| Radiology | PDP-8/Varian 620i |

*Letters & Science*

| | |
|---|---|
| Behavioral Cybernetics | CDC 160A |
| Chemistry – Instr. Service Ctr. | Raytheon 706,<br>3 NOVA's; 2 Varian 620's; Bruker |
| – Light Scattering | PDP-8 |
| – Viscoelasticity Lab. | Varian 620 |
| – Electrochemical Research | Raytheon 706 |
| – Rheology Lab. | Varian 620 |
| – Laser Lab. | PDP-8 |
| – Chemical Reaction Lab. | PDP-8 |
| – Microwave Spectroscopy | Raytheon 704 |
| Communication Arts | PDP-12 |
| Communicative Disorders | Nicolet 1070 |
| Computer Sciences* | Datacraft 6024/3; PDP-11 |
| Geophysical & Polar Research | PDP-8 |
| Meteorology | PDP-11/40, EMR 6130 |
| Physics – Adv. Lab. | SCC 4700 |
| – Atomic | Varian 620 |
| – High Energy (Thompson) | CDC 924; PDP-11/40 |
| – Nuclear | DDP-124 |
| – On-line Experiment | SCC 4700 |
| – Plasma | PDP-11 |
| – SATR | SCC 4700 Optics |
| – Space | Varian 520 |
| Primate Research Center | PDP-8 |
| Psychology | PDP-8 |
| Psychology (math) | 2 PDP-8's |
| Psychology (clinical) | 2 PDP-12's/Linc |
| Social Science Statistics | Hazeltine 200 |
| Space Astronomy Lab | PDP-8 |
| Space Science & Engr. Center | Datacraft 6024/5 |

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*Center serves as a remote-job-entry batch terminal for MACC and as an independent unit.

**Center serves only as a remote-job-entry terminal for MACC.

the College of Engineering has had considerable success in providing general batch access of a minimal-job nature without project justification or funding. The recent publication of the Dartmouth experience shows that this can be extended to a large group of customers with very little change in the computing use pattern.[1]

*More complex research and instruction.* This includes extensive use of standard programs, elaborate on-line data accumulation, development of new programs and systems, maintenance and use of special data bases, and many other applications. At Madison, computers are now used in all phases of university activity. For each of these three different categories, different methods of evaluation must be used.

## RESEARCH AND INSTRUCTION

For the more complex research and instructional use, computing evaluation must be an integral part of program and project evaluation, and of the decisions which control future plans. By funding computing, at least partially, through project funds, computing evaluation is tied to budgetary project control. Accordingly, routine operations at Madison's established general-purpose centers (both MACC, and the auxiliary centers listed in Figure 1) are funded largely through project receipts. Campus-wide funds are reserved for program and system development work, and for general consultation services.

To guide the development of the centers, the project receipts are based on item prices, rates which reflect, as much as possible, the actual costs of the particular services priced. Figure 2 shows the various categories of charges together with estimated sales credits for the recently-installed Univac 1110 at the main academic computer center (MACC). During the first few months of actual experience sales credits have generally matched the estimated distribution, although time-sharing use was a higher percentage of the total. The overall level of use is also somewhat higher than expected. Note that receipts for batch use are distributed into wholesale and retail charges. All customers pay wholesale charges, and, in general, pay retail charges as well, either to MACC or to the operator of a special MACC-terminal.

At MACC, as at most centers, multipliers are also used to level the load through the day and the week. The current multipliers are shown in Figure 3 together with the resulting estimated revenue distribution by priority-level. Similar item pricing is applied at the other auxiliary centers, although the particular items charged may differ depending on the computing equipment and the users served.

The net effect of item pricing is to let the user make decisions about the value of computing for particular purposes. There is no attempt to pre-judge or force decisions by deans, department chairmen, or research

Figure 2. Revenue Distribution from Item Pricing at Madison Academic Computing Center

| Charge Category | Estimated 1974 Sales Credit (M$) | | |
|---|---|---|---|
| | *Wholesale* | *Retail** | *Total* |
| *Batch* | | | |
| CPU/hour | 296 | 0 | 296 |
| I/O/hr | 178 | 0 | 178 |
| Memory/1K/hr | 118 | 0 | 118 |
| Card reader/100 | 27 | 38 | 65 |
| Pages | 87 | 73 | 160 |
| Cards punched/100 | 3 | 14 | 17 |
| Tape mounts | 37 | 0 | 37 |
| Extra tape mounts | 1 | 0 | 1 |
| Job charge | 28 | 44 | 72 |
| Ditran charge | | 4 | 4 |
| Subtotal | 775 | 173 | 948 |
| *Timesharing* | | | |
| CPU/hour | | | 13 |
| I/O/hr | | | 18 |
| Memory/1K/hour | | | 7 |
| Input Lines | | | 0 |
| Output Lines/57 | | | 2 |
| Tape mounts | | | 2 |
| Extra tape mounts | | | 0 |
| Job charge | | | 3 |
| Connect minimum/hr | | | 5 |
| Interaction charge | | | 3 |
| Subtotal | | | 53 |
| *Files* | | | |
| File charge/day | | | 22 |
| Mass storage/track/day | | | 99 |
| Subtotal | | | 121 |
| TOTAL | | | 1123 |

*Retail sales credits for MACC-operated terminals only.

**Figure 3. Revenue Distribution by Priority at Madison Academic Computing Center**

| Service Class | Multiplier (for Total Bill) | Estimated 1974 Sales Credit (M$) |
|---|---|---|
| *Batch* | | |
| Express | 2.0 | 20 |
| Standard | 1.0 | 618 |
| Overnight | .8 | 175 |
| Weekend | .4 | 62 |
| While-You-Wait ($1.00 job max) | 1.0 | 55 |
| Ditran | 1.0 | 18 |
| *Timesharing* | | |
| Day | 1.0 | 43 |
| Evening and Saturday | .7 | 7 |
| Late Night and Sunday | .3 | 4 |
| *File Storage* | | 121 |
| TOTAL | | 1123 |

investigators. If the particular department chairman or research investigator feels the use is worth the cost, s/he can use department or project funds to pay for it. This presumes a certain consistency and reliability in terms of future planning. The campus must make certain long-range investments and must insure that changes in use pattern occur only after enough advanced warning to allow a matching of the facility with the demand. Fortunately, shifting of funds between categories, while possible, is sufficiently controlled to prevent extreme or rapid departure from budgeted fund distributions.

Other alternatives open to the decision-makers are to seek outside services or to justify new equipment for a particular research or instructional project. State and university policy requires clearance of outside services or new equipment by the State Department of Administration, based on a thorough review at the campus level. At Madison, this review is provided through a campus-wide committee of faculty and administrative staff, which is chaired by the Coordinator of Computing Activities. The committee has been trying to make sure that plans for use of outside services or acquisition of new equipment are made with a proper recognition of existing campus services that might do the same job. In several cases, review led to a switch from a stand-alone, independent center to a facility tied to the main center, which could provide both stand-alone capability and access to the large central computer. With any such facility, the committee usually requires an evaluation of the costs of using the central computer for the same purposes before granting approval for the purchase of new equipment. Nevertheless, a determined research investigator with a really good plan to use new computing equipment and funds for these plans, usually finds it quite easy to justify purchase of his or her own equipment.

## GENERAL ACCESS USE

Item pricing and detailed cost balancing is not a suitable basis for evaluating general-access computing. The most convenient way to provide general access use campus-wide is to allow access without previous justification to any person registered on the campus. For a service like this currently planned at Madison, justification of the costs will depend on general support by the academic deans. If the costs seem reasonable to them, in terms of the academic benefit, the service can be maintained. This has certainly been the case in the College of Engineering, which has funded such general access computation at a level of at least $100,000 per year for many years.

## ADMINISTRATIVE COMPUTING

Methods for evaluating administrative computing and data processing are not as well established. At the University of Wisconsin, there are more questions than answers. Some administrative computing is funded by transfers from other accounts, chiefly for auxiliary services such as dormitories and athletic programs. However, the bulk of administrative computing is intimately connected with the data base for the campus. Proper sharing of costs among the various services is difficult to establish, and overhead funds are supplied directly; the budget level is set by the Chancellor's office. This is not entirely satisfactory. One apparent difficulty with this procedure is the evaluation of priorities for development of new administrative services where apparent needs exceed the available budget. There is a long backlog of potential uses which seem interesting and attainable if staff could be assigned to develop them.

Much of the background for this discussion comes from a campus computing plan developed in 1974 which received wide input from faculty and administrators concerned with computing. The plan is rather bulky, running to approximately 60 pages. However, for distribution to those who are sufficiently interested, a limited number of copies are available from the author.

## REFERENCE

1. Luehrmann, Arthur W. and John M. Nevison, "Computer Use under a Free-Access Policy", *Science, 184,* 957-961 (31 May 1974).

# Evaluating Computing Services at the University of Minnesota

by Frank Verbrugge

In these days when computing service involves far more than having a hardware facility available, it is worth recalling that not too many years ago the computing operation was analogous to that of a coal mine, to which a customer brought his own bucket and shovel, groped around in the dimly-lit mine, loaded up and took his pail of coal home with him. Computing in academic institutions has undergone dramatic changes, and in assessing the effectiveness of service provided one must consider not only the hardware and its availability but also many related services.

A total computing budget at the University of Minnesota is impossible to define because funding takes place within departments and colleges where expenditures are related to computing but which are never identified formally as part of a computing activity. At the University of Minnesota as at most universities the formal structure is encompassed mainly within four categories.

- Instructional and research computing including a large component of public service functions;
- Administrative data processing;
- Specialized computing service systems such as a hospital system, a library system, and similar systems offering service to either a general or a specialized clientele; and
- On-line facilities usually operating in a real-time mode and associated with scientific research apparatus.

Responsibilities of the Office of University Computer Services at the university encompasses in some way ~~all~~ of the systems named above, but are largely centered on instruction and research systems. This service is provided by seven computer centers, four of which are located on the Minneapolis-St. Paul campus and three of which are located at branch campuses. The system is integrated and interconnected system with a CDC 6600 as the major node, operated by the University Computer Center and a timeshared computing service is managed on a statewide basis through MECC. (See Chapter 5) Prior to 1974-75 this system was managed by the University Computer Center but will become a consortium operation next year. Funding for the instruction-research system arises about equally from direct University support including legislative support, and support from research sources. For both instruction and research application on the timeshared capability, the total university usage of this system for 1974-75 will exceed $300,000. Another $3.5 million is done in the batch processing mode. Remote access to the 6600 is provided locally by approximately 20 RJE terminals. Access to the timeshared system is provided by more than 100 teletype terminals most of which are located in eight all-university computing laboratories of ten to twelve terminals each. In summary, the described system is quite extensive and one major goal is to develop and maintain a hardware capability as needs develop.

The role of Director of University Computer Services at the University of Minnesota encompasses long-range planning, and fiscal management of instruction and research computing facilities plus an overall watch-dog role with regard to facilities for the four types of systems. For instruction and research computing the control is fairly determinative because the University's support budget is approved by the director. The administrative data processing facilities are essentially planned and operated independently. Coordination takes place in the all-University budgetary planning, and at the operating level, by having staff members of University Computer Center serve on a Technical Advisory Committee for ADP.

The specialized service systems are also quasi-autonomous, primarily because the funding is provided by the clientele using the services. The library is an exception, because it is university funded. This system is just in its initial stages of development at the University of Minnesota, but staff try to maintain the same review process through an Advisory Committee on University Computer Services for these facilities as that which applies to instruction and research systems.

On-line computer facilities for specific research apparatus are also reviewed by the director although the number of such facilities is no longer as great as it was three to four years ago. Federal agencies in 1974 are providing less specialized computing facilities. If the facility has been funded a statement is requested from the director of that facility in which he or she agrees that the system will not be used as a production system (no services will be sold on the system) and that, if the sponsoring agency eliminates support for the facility there is no commitment by the university to provide budgetary support. Beyond that acquisition of small computers, like that of mass spectrometers or gas phase chromatrographs, is subject primarily to the peer review process, and the effectiveness of the services provided is the responsibility of the principal investigator.

Computing facilities and budgets for all educational systems in Minnesota are now subject also to review by the Minnesota Educational Computing Consortium. The primary emphasis of MECC is general purpose systems; hence, with regard to the university, instructional research and administrative data processing computers are its primary area of concern.

A second role of the Director of University Computer Services is that of budget officer, a line position with budgetary responsibility reporting to the Academic Vice President on exactly the same basis as the deans of the several colleges. All University support for computing for the instruction-research system is channeled through the director's office. Directors of the individual centers plan their budgets with the Director of University Computer Services on the same basis that department heads plan their budgets with deans. Each computer center director retains an individual income from services budget and plans his or her total operation on the combined sources of support and income. The expectation of the university is that every computer center director must come out even and that the Director's office covers any deficits which arise without supplementary support from central administration. The net result is that both the computer center directors and the Director of University Computing exercise a fairly close watch on a month by month basis. The director has a discretionary budget item which can be used either for equipment acquisition or for operating support with primary emphasis on equipment acquisition.

As a line officer of the University the director participates in the all-University budgetary planning sessions where the computing budget is a categorical budget which is reviewed separately from the collegiate budgets and is also submitted to the legislature as an identified budget. In the budgetary allocations, the director works with the individual computer center directors, and the college deans and the department heads are not involved. This approach is analogous to the budgetary management of most libraries. In that case, however, individual departments typically submit a departmental library request which is then used by the library in planning its overall request. For computing at the University of Minnesota even that process does not take place. The colleges and the departments are provided a computing service essentially at no cost to them. The one exception is a charge which is assessed for supplies and for the use of peripheral equipment such as tapes and printers, which is paid from the departmental supply budgets. That charge at the same time becomes the basis for local control which discourages unrestricted utilization of a "free resource".

The delivery of computing service is also an all-University operation in which the office of the Director of University Computing interacts directly with the professors and students who need the service. In practice the operation follows three steps. First, for any course that requires computing, the professor provides the computer center director or administrator with a list of students enrolled in the course. These students are then given account numbers. Secondly, for graduate students who require thesis related computing, the thesis advisor co-signs on behalf of the student and specifies whether s/he has research support for computing and, if so, to what extent. On this basis the graduate student is allowed access to the computer to meet his/her thesis needs; the approval of the service is virtually automatic. Finally, the major area of computing support is for research computing. For this purpose a Computer Grants Committee consisting entirely of members of the faculty, reviews requests for computing grants for unsponsored research from a fund controlled in the office of the Director of University Computing. Unsponsored research is either completely unsponsored or partially sponsored as far as computing is concerned. Because the Computer Grants Committee has established a number of policy guidelines, most of the small grants are handled administratively at the computer center and only the major projects are reviewed in detail by the committee.

General policy for the office of the Director of University Computing is provided by a faculty advisory committee for university computer services. This faculty committee is responsible for long-range planning particularly concerning facilities and for endorsement of the approach to budgetary planning. In a given year, there may be several task forces which report to the committee such as task forces on time-sharing, computer-aided-instruction, data base management, and statistical programs, which have been established during 1974.

With regard to the statewide timeshared system, full support is provided from the office of the Director of University Computing for the all-University instructional computing laboratories. Instructional terminals in individual departments are funded jointly by the office and by the department, and research terminals are funded entirely by the principal investigator of the research project.

Although the system is highly centralized in planning and in fiscal management, it is highly decentralized in its services. Staff hears directly from the faculty users what the problems are, and a very effective Manager for User Services takes remedial action. The response time on a request for dollar support is kept as short as possible and a response is given directly to the user. Because budgetary planning is approached in a mode which is the equivalent of that used by most traditional units at the university, computing resources are highly visible in centralized university planning. In 1974 from the point of view of facilities and of finances of the office is in a relatively sound condition. The staff continues to pursue the goals of having an ear tuned to user needs and responding quickly and directly to budgetary needs without going through the conventional university structure.

# Chapter 11

## Management Information Systems

### National and Statewide Management Information Systems Efforts in Higher Education

by George W. Baughman

In developing a perspective on the history and trends in the development of national and statewide management information systems in higher education I find Walter Kennevans' definition of a management information system most helpful. It separates large operational or statistical data gathering activities from those designed to serve management. He states, "A management information system is an organized method of providing past, present and projection information, related to internal operations and external intelligence, that supports the planning, control, and operational functions of an organization by furnishing uniform information in the proper time frame to assist the decision process.[1]

With this definition, very few national and statewide efforts could be called MIS since frequently they fail to: provide past and projection information; relate internal operations to external intelligence; support the control or operational functions; or meet the proper time frame to assist in the decision process. In short, many of the current MIS efforts are simply organized methods for providing present data related to internal operations that, if they happen to get published, may help someone in the planning function.

## NATIONAL MIS EFFORTS – A SEARCH FOR STANDARDS

Most of the national MIS effort has been directed to developing standards for data collection and exchange. The most vigorous early work in this area was undertaken by the National Standards Committee appointed by the U.S. Office of Education in 1930. Recently, the National Commission on the Financing of Postsecondary Education and the National Center of Higher Education Management Systems at the Western Interstate Commission on Higher Education (NCHEMS/WICHE) have revived the drive for standards and provided the rudiments of a national MIS.

*National Standard Commission 1930-33.* Lloyd Morey, then Controller and later President of the University of Illinois, chaired this valiant effort, mounted in a time of dire financial circumstances for higher education. During a three year period his committee produced seven bulletins[2].

The first two reports served as the basis for the financial reporting standards of the National Association of College and University Business Officers published in 1954, 1968 and soon to be released in 1974. The third bulletin, published in 1932, provided an analysis of some forty-four different methods of calculating per student costs and in many respects is still superior to the work of the National Center of Higher Education Management Systems in the late 1960's and early 1970's[3]; or the recent "Interim National Procedures for Deriving Standard Unit Costs" of the National Commission on the Financing of Postsecondary Education (NCFPE)[4]. In 1931 the committee concluded that "There is an urgent need for a recognized technique for the computation of unit costs if these costs are to have any value outside the individual institutions in which they are calculated." This was largely ignored.

The fourth bulletin provided standard object of expense codes which properly displayed the unique expenditure categories common to higher education and, at the same time, were a compatible subset of the Federal Government Accounting Office coding schema. The codes were numeric and hierarchly assigned which made them excellent for automation. They were not republished or generally adopted. Had they been, federal reporting today would be infinitely simpler as would implementation of most of the recent recommendations of the NCFPE for common reporting of data and national price indices for postsecondary education.

Bulletin five was directed to internal financial reports and recommended budget reports that included a technique for forecasting and reporting "exceptions." In general, these recommended reports are superior to those received by 95% of the budget officers in higher education today.

Standard enrollment and full-time equivalent student reporting was the subject of bulletin six. This was revolutionary by today's standards in that it provided a clear discussion of the logistical and statistical problem of establishing a common point in the calendar for "counting" and addressed the thorny issue of non-credit enrollments and full-time equivalencies of these enrollments in a very direct way.

The seventh bulletin dealt with the reporting of auxiliary activities and provided excellent suggestions in the difficult areas of Medical School Hospitals and Athletics. In addition, it provided an insightful discussion of depreciation for different kinds of university property holdings.

Unfortunately the work of the National Standards Committee is largely unknown in higher education today. However, this illustrates dramatically that MIS efforts are neither new nor a linear trend. Had the recommendations of the committee been followed universities would have had the rudiments of a national MIS by the mid to late 1930's.

## A FORTY YEAR GAP

Better financial times returned in 1934 and then the war, which was followed by a "war veteran" and then a "war baby" boom. These consumed most of the attention of higher education for nearly forty years and standard reporting, cost accounting and the like were put on the back shelf.

One exception to this "forty year gap" was a major cost finding effort mounted in the mid 1950's by the Big Ten and Western Conference institutions. This unit cost by discipline study provided a disappointing testimony to the continuing problem of non-comparable data. The modest findings were released without fanfare, without actual numbers and with great reluctance on the part of the participants. This study, in part, provided the impetus to develop common elemental data definitions among the Western Interstate Commission of Higher Education Institutions (WICHE) in the mid-1960's.

## WICHE AT HEGIS

The Department of Health, Education, and Welfare combined all of its various institutional questionnaires on enrollments, space, financial, personnel, staffing, salaries, students, student migration, continuing education, administrative officers and degrees in one mailing package in 1966 and called it the Higher Education General Information Survey (HEGIS).

This first step put institutions on notice that a comprehensive approach might finally be taken to the myriad unique federal data gathering exercises. However, each of the sub-surveys still incorporated unique definitions which arose from the use of "specialist" review groups for each questionnaire to design and approve the next year's version. Data were not standard among the different surveys or within different years of the same survey. A continuing consensus group with comprehensive concerns was needed, and the WICHE consortium that was working on common data elements offered to be that group in 1969.

From 1969 to 1971 the WICHE group, then called the Planning and Management System (PMS) Division, spent most of its efforts in developing standard data element definitions in the student, personnel, facilities, financial, and courses area and in constructing a taxonomy of academic programs. The WICHE/PMS project received its major financial report from the Department of Health, Education, and Welfare for projects that would directly improve the capability of institutions to provide standard data.

In 1971, the work of the WICHE/PMS Division had received major national attention because of massive task group involvement, large scale distribution of products and the incorporation of its products into the HEGIS survey. The project expanded into a federally funded National Center of Higher Education Management Systems (NCHEMS) at WICHE and the original work towards HEGIS reporting standards has continued under the aegis of a national rather than regional umbrella.

## POSTSECONDARY COMMISSION AT HEGIS

The HEGIS surveys, which result in massive amounts of data or enrollments, degrees, personnel, facilities and financial aspects of virtually all of the institutions of higher education, have seldom been used in a comprehensive way to provide "management", in this case congress and the executive branch, with timely policy forecasts or analyses. Timeliness has been a major problem since even summaries of the data are frequently published two to five years after the data are collected.

U.S. Office of Education projections have historically made limited use of national totals from HEGIS data. The first comprehensive attempt to use HEGIS data for policy analysis occurred in 1973 when the National Commission for the Financing of Postsecondary Education created a number of on-line analytical data basis from HEGIS and other files. George Weathersby provides a detailed discussion of the construction of that data base in a staff report of the commission which was presented by Daryl Carlson, James Farmer, and Richard Stanton at the College and University Systems Exchange meeting in December 1973[5].

The use of HEGIS and other nationally collected data by the National Commission for the Financing of Postsecondary Education to explore the relationship of fees to enrollments in public higher education and other economic characteristics of postsecondary education is the first generation of a "management information" product from the HEGIS Surveys. That it took over eight years to achieve is instructive to those who would build MIS systems. The fact that this "management" dimension was added to the basic data collection at a very modest cost suggests that the rudiments of a national MIS are here and will likely stay.

## NCHEMS: THE KEY TO A NATIONAL MIS

Efforts in the past forty years have clearly demonstrated that an effective national MIS will require: a consensus seeking group; a highly qualified technical support staff to create and implement integrated products; continuity of financial support and technical leadership; and a comprehensive scope of problem definition that embraces all of the aspects of institutional activity. On each of these criteria the NCHEMS effort emerges as a leader. An elaborate structure of institutional representation on task forces, review panels, and so on, provides the consensus mechanism. Products are created by technical support staff and consultants drawn from the institutions, and their work is coordinated, augmented, and expedited by a reasonably small staff at the NCHEMS offices in Boulder. Implementation is assisted greatly by staff conducted workshops, extensive publications and the use of pilot "member" institutions. Financial continuity, while not assured, has a high probability of success. The designation as a federal national center carried a $1,000,000 per year budget subsidy and the NCHEMS project menu is varied enough to assure that foundation and state agency contracts can be attracted. Technical and political leadership is certainly at a high point since most other potential competitors are advised to check with, coordinate with or join with the NCHEMS effort. In addition, the selection of the Executive Director of NCHEMS to serve as the Director of the staff of the National Commission on the Financing of Postsecondary Education in 1973 had significant value. The work of that commission was clearly supportive of many of the NCHEMS projects.

In short, there appears to be little question as to who will design and test "national" MIS projects. One remaining question is who will be responsible for data collection and analysis? At this point it appears to be a toss-up between a revitalized National Center for Educational Statistics and NCHEMS.

## OTHER NATIONAL MIS EFFORTS

Although the major national MIS thrust is embodied in the NCHEMS/HEGIS/national commission work there are four other efforts that are worthy of note at a national level.

*A.A.U.P. Compensation Survey.* Although not generally recognized as an MIS effort the American Association of University Professors annual compensation survey meets most of the tests of an MIS. Started in 1959, the survey each year has included past and present data on average salaries by rank for each institution. Forecasted values for each of the next two years are provided and the surveys are published in April preceeding decisions that are usually made in June or August. During the 1960's more attention was paid to and more resources were directed as a result of A.A.U.P. data than any other single source of information in higher education.

*American Association of Collegiate Registration and Admissions Officers (AACRAO) Enrollment Projections.* In 1953 Dr. Ronald Thompson used U.S.O.E. data on opening fall enrollments and census data on 18-21 year olds to forecast college age population trends to 1970 and accurately predicted the tidal wave of students that would hit higher education in the 1960's. This survey was monitored by Thompson and updated in 1961 to forecast to 1978 and again in 1970 to provide forecasts to 1987.

These projections, supported by AACRAO, provided estimates of public and private enrollments by state, by year and could readily be used as aggregate projections by statewide and national "managers", particularly in the public sector. In addition, they are simply constructed and can readily be updated with published data.

During the 1960's, Thompson seldom missed by more than 2 to 5%. He did not forecast the drop in attendance rates for the early 1970's and so his current projections are too high. They still represent a valuable source of data for those interested in forecasting traditional markets for higher education.[6]

*Chambers/NASULGC: Appropriations.* Since 1959, Dr. M. M. Chambers has provided the only timely and consistent source data on state tax support of higher education in the 50 states in a monthly report called the "Grapevine."

Although this series does not meet the projection information test of an MIS, it continues to be the only available comprehensive data on state appropriations to institutions of higher education.

The specific contributors to the "Grapevine" from each state are known only to Chambers. The data are usually published within one or two months after the appropriations are made, are extensively footnoted and identify institutions. An annual composite is published by the Office of Research and Information of the National Association of State Universities and Land Grant Colleges (NASULGC) in October of the fiscal year and publications summarizing the 1959-60 through 1968-69 and 1969-70 through 1972-72 are available.[7]

*Equal Employment Opportunity Commission.* The national effort to assure minority and women's rights will be the major force in the development of integrated management information systems in higher education in the 1970's. What started in the 1960's as a requested statistical report estimating the number of minority employees and students now virtually requires detailed person by person records with elaborate classification coding.

For example, the proposed E.E.O. form for educational institutions for 1974-75 will include:

- Full-time staffing statistics by sex, race, occupational activity class and salary range;
- Distribution of faculty by sex, race, tenure status and rank;
- Distribution of "new hires" by sex, race, occupational category, and tenure status;
- Distribution of part-time personnel by sex, race, occupational category, and tenure; and
- Staffing by sex, race and source of funds.

The surveys, in theory, (and in the legislation) can be done by visual counts. In practice other requests for information are likely: 1) on-site investigations of claims; 2) other more detailed supporting information requests (applicant and salary history, unit salary comparisons over-time, etc.); and 3) goals with respect to new hires, employment patterns, and salary levels. This virtually forces the development of an integrated personnel system.

Faculty and staff are of equal importance from this new personnel viewpoint. Since over 80% of most institution's expenditures are for personnel and since few institutions have historically provided "equal systems" for faculty and other staff the impact on most institutions is enormous.

Although the word MIS is never mentioned in E.E.O.C. literature the fact that past, present and future information that reflects operational fact in a time frame that can be nearly immediate makes it the strongest force for a national MIS. The fact that the 1974 occupational categorizations are NCHEMS derived also adds support to the contention that NCHEMS will design a national system.

## STATEWIDE APPROACHES TO MANAGEMENT INFORMATION SYSTEMS

There are a number of major efforts to develop statewide management information systems. Charles Mosmann's forthcoming publication on higher education MIS efforts will deal with most of them. Although one could recite the litany of states and their approaches, the general shape of statewide MIS efforts can be seen through the Ohio model.

*The Ohio Model.* John Millett was selected as the first Chancellor of the Ohio Board of Regents in 1964 and became the "author" of the system. Drawing upon his experience in the early 1950's as Director of the Carnegie Commission Study on the financing of higher education and his later experience as President of Miami University (Oxford) he designed course level, program budget models that became the basis of the system. It is instructive to note that the budget models were designed, articulated and used in 1965, some two years before the supporting data systems caught up. In other words, management had decided what it needed for decision-making first and the issue of supporting data systems became the cart behind the management horse. The elements of the data system were to serve two purposes:

- To provide a resource analysis of the people, space and dollar requirements to support a given level of instruction in a particular discipline grouping;
- To provide statistical profile information in a common format about students, faculty, staff, space and finances.

The features of this system are common to most statewide MIS efforts although the details may vary greatly.

*Transactional Activity and Inventory Data.* In 1966, institutions of higher education in Ohio began supplying activity and inventory data in a common, machine readable format to the Ohio Board of Regents. For the most part, the data were transactional rather than summary and were classified using standard rather than institutional codes. For example, a student inventory record providing age, county of residence, standard rank, cumulative credit hours, standard degree program, sex, marital status, etc., and a student activity record indicating each course, section and credit hour value along with a subsidy eligibility code is provided for each student, each term, as of the 14th day of enrollments. This is the student data base. It is used to provide statistical profiles, to calculate subsidy earned in accordance with the course subsidy model and to provide the output divisors by discipline and course level for the resource analysis.

Similarly, individual room and building inventory and classroom or lab activity records are submitted to establish space resources and usage. Individual faculty and staff inventory and faculty service reports are submitted to describe personnel characteristics and for use in allocating costs to course levels.

Financial data are provided on a budgeted (annually) and actual year to date (quarterly) basis in summary form, by source of funds and academic program or support program area. Finally, a course inventory file is submitted identifying each course taught and its level. The student enrollment file is used to show activity in each of the courses.

These five data bases on students, faculty/staff, courses, facilities and finances are the ones most generally identified with statewide MIS efforts. Some states will go further than the Ohio system and try to provide central transactional processing capability (e.g., admissions, payroll, registration). Some states will request only summary information (e.g., copies of HEGIS reports), and some states will continue to accept institutionally defined data in traditional budget format.

*Program Subsidy Allocation and Control System.* Development of the student and course data bases in 1966 permitted the statewide calculation of subsidy entitlement in accordance with the course level subsidy models. Automated subsidy calculation was installed in 1966 with an associated detailed audit of student records selected by sampling. The Ohio system uses one-third of summer course enrollments plus all of fall course enrollments to estimate an annual F.T.E. This means that the actual subsidy earned is known in November. Institutions receive monthly checks from the state. The checks for July through December are each for one-twelfth of the estimated appropriations and the January through June checks are adjusted to reflect actual earnings based on the subsidy calculation.

For auditing purposes, a stratified sequential sample is drawn. This ranges from 2 to 10% of the records of the students at a given level. Listings of student numbers are sent to the institutions in advance so that the original copy of student registration records are ready for the auditors when they arrive. Adjustments can be made to appropriations to reflect major errors detected in the audit (on the assumption that the sample represents the population). If the sample audit reveals errors that would effect appropriations by five percent the regulations require a full audit of all student records by an outside independent agency. In the past eight years no such audits have ever been required and the actual audit findings place the reliability of the data well over the 99% limit.

Although this particular program subsidy allocation and control system may be unique to Ohio it is a general procedure that could be expected in any state that uses budget models for establishing tentative allocations and then adjusts appropriations to reflect actual experience.

*Resource Analysis Model.* personnel and instructional space resources are allocated to each course level within each academic program based on data supplied in the student, course, faculty, financial, and space activity files. Because calculations are performed with budgeted data after budgets have been adjusted to reflect actual subsidy, they can be performed in February or March in order to make adjustments in budget models for July.

The resource analysis model does not forecast costs, personnel or space requirements, nor is there a direct or automatic relationship between the findings of the resource analysis and subsequent adjustment of budget models. It does provide standard cost, personnel and space use data by common program and level for all state assisted institutions. Furthermore, it provides it in a format that is directly comparable with the models being used in budgeting.

Ohio has the longest history (six years) of using a standard resource analysis procedure. There is no question that this kind of output, particularly the "what does it cost?" component, is of great interest to statewide and national legislative groups. At the same time one must recall that the eight course level budget models preceded the resource allocation procedure and thus largely defined which costs and what format. Although nearly 300 program/level cost cells exist, such as English/General Studies or Physics/Ph.D. they have not been used to impose or even suggest a uniformity goal among the thirty-six different institutions. This does not mean that some university trained legislative analyst won't do a "least cost model" by extracting the lowest cost institution for each of the program/level cells. It just means that with six years of actual data no such obviously gross and distructive misuses of the data have been made.

Ohio is currently revising its budget models to more explicitly account for inflation, to accommodate continuing education in a more direct way, and to become somewhat more discipline cost sensitive. The changes in the budget models will likely be followed by changes in the resource allocation procedures where required.

*Internal Management Practices.* A logical outgrowth of any MIS effort is a concern for improved internal management practices. Obviously the ability to provide reliable and consistent data from a variety of sources in a common format is one test of management capability. Ohio institutions met this test in the mid-1960's.

More germane to the specific question of management ability are the policies, procedures, practices and "results" of an institution. In 1973, the Board of Regents, under legislative direction, undertook a formal management improvement program. The first step of this program was to develop manuals of suggested best management practices in the areas of: student admisssions and registration; program budgeting; computing and data processing; personnel; and planning. Task forces were established for the twelve universities and also for the twenty-four two year, community college and technical institutes in each of these five areas.

Ten manuals were written by the task forces with coordination and staff services being provided through the regents under the capable leadership of Jerry Shawhan which are currently being published.

As a follow-on during 1974, there will be pilot projects implementing various recommended practices at different institutions, and the initiation of studies of practices in the financial management, and selected auxiliary services areas like housing, dining halls, student unions, and bookstores.

Again, these particular studies may be unique to Ohio, however, the fact that the Academy for Educational Development has announced intentions to publish and distribute these first manuals to all institutions of higher education suggests that the interest is not just local. Also, the pattern of MIS development followed by increased interest in the management process is likely to be a typical one in the remainder of the 1970's.

## MIS IS STILL JUST AROUND THE CORNER

Currently there are far more people working on standard data than on systematic use of that data for decision-making. However, the Ohio experience suggests that once a systematic decision model is adopted, true management information systems can be implemented. When systematic models, such as the Ohio model or the ones proposed by the National Commission on the Financing of Postsecondary Education are adopted by national or statewide agencies for funding higher education they provide great impetus for a management information system. At that point one can expect to see the large payoff in the data standardization and data gathering activities that have been going on for the last ten to fifty years.

Also, at that point one can expect any national or statewide MIS effort at a minimum to: 1) include timely past, current and projected information about students, personnel, facilities, courses and finances; 2) make use of these projective, historical and current data in support of models; 3) provide sufficient transactional or translatable data to permit detailed audits and controls; and 4) stimulate related work in the actual management practices of the institutions.

From a standpoint of systems that provide organized methods of presenting internal and external data in an historical, current and projective mode for timely use by decision-makers, most national and statewide MIS(s) are still just around the corner.

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# A Summary: CBMIS

**by Richard L. Mann**

In 1973 a study* was made to determine the extent to which computer based managment information systems (CBMIS) are being developed and used by colleges and universities throughout the country. In the study a CBMIS was defined as: a computer based management information system used to store, manipulate, and retrieve data for management planning and resource allocation purposes. The CBMIS is distinguished from standard data processing applications such as payroll or student records in that it emphasizes the capability to rapidly integrate and display data from various files, both current and historical, and to assist administrators in planning, resource allocation and general mangement decisions.

This study which was based upon the completion of a survey questinnaire mailed to 722 institutions throughout the continental United States, explored seven major areas:

- To what extent are academic institutions to developing CBMIS?
- What factors have caused academic institutions to begin development of CBMIS?
- How is the CBMIS project organized?
- What role does CBMIS play in institutional management and reporting?

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- What are the components of CBMIS in higher educational institutions?
- What impact has the Western Interstate Commission on Higher Education, National Center for Higher Education Systems (WICHE-NCHEMS) had upon CBMIS development in academic institutions?
- What is the impact of CBMIS on university administration?

A number of institutional demographic characteristics were used to analyze the data returned by 66 percent of the institutions surveyed: campus type with categories a) single campus, b) system office for a multi-campus system, and c) campus in a multi-campus system; enrollment with categories a) 3000-6000, b) 60001-10,000, c) 10,001-15,000, d) 15,001-20,000, and e) 20,001 and over; control with categories a) public and b) private; and highest degree offered with categories a) Associate, b) Bachelors-Masters, c) Doctorate.

## EXTENT TO WHICH ACADEMIC INSTITUTIONS ARE DEVELOPING CBMIS

Of 430 institutions responding to the question "Is your institution planning or implementing a CBMIS?" 69 percent replied affirmatively. Forty percent of these institutions reported their CBMIS in partial operation, 28 percent indicated they were still in the planning stage and less than one percent of the schools stated that they had fully operational CBMIS. More than half of the institutions reporting no CBMIS activity indicated that they intended to develop a CBMIS in the future.

Although no statistically significant differences relating to CBMIS development were observed when the data was analyzed by demographic characteristics, a number of interesting tendencies were observed. First, multi-campus institutions and public institutions reported CBMIS activity more frequently than did other institutions. Schools with larger enrollments, especially over 20,000, showed a slightly greater percentage of CBMIS involvement; and it was observed that the higher the level of degree offered the greater the percentage of institutions which were engaged in CBMIS development.

When the length of time CBMIS institutions have been planning and operating their systems was analyzed, the data showed that public institutions have been planning and implementing CBMIS somewhat longer than private schools. Multi-campus institutions have been engaged in CBMIS planning significantly longer than single campus schools, although single campus schools reported significantly more progress in terms of actually implementing CBMIS. With larger enrollment the institution was likely to have been engaged longer in both planning and implementing CBMIS; and in both public and private institutions the greatest percentage of schools reported that they began their CBMIS planning and implementation activities between one and three years ago.

Survey responses suggest that the longer an institution has been using a computer for administrative purposes the more likely it is that the school is planning or operating a CBMIS. However, little relationship between the length of time an institution has been engaged in administrative computing and the length of time it has been planning or operating a CBMIS could be found. Finally, the development of CBMIS appears to be independent of whether the host computer is dedicated to administrative work or is a shared administrative/instructional machine.

## FACTORS RESULTING IN CBMIS DEVELOPMENT

Respondents were asked to rank the most important reasons for their institutions' beginning CBMIS development. "To improve internal management" stood out as the most important with 229 institutions out of 239 ranking this reason first. The next most important reason specified was "support of other management tools" followed by "to meet state reporting requirements", which was ranked high by public institutions.

The Vice President for administration, planning or finance was the individual cited most frequently as the primary initiator of the CBMIS project followed in importance by the President, Director of Data Processing and the Director of Institutional Research. Private institutions, however, reported the Data Processing Director as most responsible for initiating the CBMIS project followed by the Vice President, the Director of Institutional Research and then the President. The President was cited most frequently as the highest level of administrative support which the CBMIS project had received.

## ORGANIZATION OF THE CBMIS PROJECT

Each institution was asked to identify by title the administrator with overall responsibility for the CBMIS project. The most frequently mentioned administrator was the Director of Data Processing followed by the Director of Institutional Research/Planning, and the Vice President or Director of Finance or Business Affairs. Forty percent of the responding institutions indicated that the chief administrator for the CBMIS reports directly to the President while another 34 percent indicated that s/he reports to the chief financial, business or planning officer of the school.

Responsibility for the design of CBMIS was assigned to the Data Processing Department according to 53 percent of the respondents. In schools of 23 percent of the respondents CBMIS design was the responsibility of the office of Institutional Research/Planning, while 12 percent of the schools reported that this was the responsibility of a specially created task force or committee. In terms of implementation responsibility, the Data Processing Department was mentioned most frequently (63 percent) followed by Institutional Research/Planning Department (19 percent) and special committees (10 percent). It appears that data processing has a predominant role in both CBMIS design and implementation.

The survey also showed that institutions developing CBMIS regard administrative support offices such as the Registrar, Personnel and Business Affairs as most important in terms of their contribution to the planning of a CBMIS followed closely by general level administrators such as the President and Vice Presidents. Academic administrators were ranked a poor third in importance and faculty and student contributions were reported as being negligible.

Slightly more than half of the responding institutions indicated that no additional funds were being allocated for CBMIS. Multi-campus system offices, however, reported a significantly higher frequency of new funding for CBMIS than was the case for other respondents. It was also noted that institutions with large enrollments (over 15,000) were more likely to create new budgets for CBMIS than were smaller schools suggesting that the smaller institution is less likely to provide additional funds for CBMIS.

## CBMIS IN INSTITUTIONAL MANAGEMENT AND REPORTING

Slightly less than half of the responding institutions indicated that they engaged in a formal study of information requirements prior to beginning CBMIS development. However, smaller institutions (under 6,000) showed a greater tendency to engage in such formal studies as compared to larger schools.

The survey sought to determine the extent to which major information areas (student, financial, staff and physical facilities) are being incorporated into the CBMIS. Student information appeared to be the most advanced followed by financial, staff and physical facilities information. A number of respondents also indicated that curriculum, alumni and library information areas were also being included in their CBMIS.

Private institutions have progressed somewhat further in incorporating financial information into their CBMIS compared to their public counterparts. A similar situation existed for student information, but physical facilities information has received greater attention from public institutions. No difference between public and private schools could be discerned in terms of their inclusion of staff information into their CBMIS.

The extent to which the computer is being used to maintain and process data for the four information areas was also explored where the order of development was the same as in CBMIS development: Student; Financial; Staff; and Physical Facilities information. As would be expected, greater extent of computer use appeared with more advanced CBMIS development reported for each area. The media used in the computerization of these information areas appeared to be primarily direct access devices followed by magnetic tape and punched cards.

Respondents were queried as to the order in which various groups within the institution were serviced by CBMIS. As might be expected it was found that the design priorities built into the CBMIS reflected the extent of each group's contribution to the planning of the CBMIS. Thus, administrative support offices followed by general administrative offices, academic administration, faculty and students comprised the priority ranking for CBMIS service. This was the same as the ranked importance of each group's contribution to the planning of the CBMIS which suggests that a CBMIS is primarily designed by administrators for use by administrators.

The second most important reason specified by respondents for developing CBMIS was the support of other management tools. The use of management tools such as resource allocation models was reported by 127 of the 296 institutions indicating CBMIS activity. Planning, Programming and Budgeting Systems (PPBS) were reported in use by 110 of the CBMIS schools while 205 of these institutions reported using institutional research techniques. Thus it would appear that the support of other management tools is in fact a major reason for many institutions' embarking upon CBMIS development.

## COMPONENTS OF CBMIS

Four major components appear to constitute most CBMIS in academic institutions. These include integrated data bases, commonly defined data elements, generalized information retrieval systems, and techniques used to insure data security.

Most respondents reported that their CBMIS data base was composed of related sub-files which conceptually form a single integrated file. Few institutions indicated that they use either a single physically integrated file or separate unintegrated files for their CBMIS data base. In addition, most institutions reported that they are using operational data processing files (such as payroll and student records) as well as specially created summary files to support the CBMIS data base. A somewhat smaller group of schools reported using only operational data files while very few institutions indicated they are using only summary files.

Most CBMIS institutions reported that many of their data elements were commonly defined, followed by a slightly smaller percentage of schools which indicated that all data elements in the CBMIS were commonly defined, and several institutions in which only a few data elements were commonly defined. Interestingly, institutions in the 3,000-6,000 enrollment range reported the greatest frequency of all data elements commonly defined which may be due to either the ease of achieving such commonality in a small institution or the relative newness of the institution to administrative computing, enabling it to begin with commonly defined data elements.

The standards used to define common data elements differed significantly between public and private schools. Public institutions reported that WICHE-NCHEMS definitions followed by state or system-wide definitions were used while private schools indicated they used their own definitions most often followed by those of WICHE-NCHEMS. Interestingly, the same percentage (35 percent) of public and private institutions report using WICHE-NCHEMS definitions.

One method of controlling data element commonality in a CBMIS is through a data element dictionary. Most institutions reported that this feature of their CBMIS was still in the planning stage while a slightly smaller percentage reported that they were implementing or had implemented such a dictionary. Although very few respondents indicated they were not considering such a system, this response was more prevalent among single campus schools as opposed to multi-campus institutions. This fact suggests the importance which multi-campus schools attach to controlling data element definitions in order to manage multiple campuses.

A majority of the responding CBMIS institutions reported planning a generalized information retrieval system for their CBMIS. A somewhat smaller group indicated that such a system was already in operation while very few respondents indicated that they were not considering such a system. Large institutions, over 15,000 students, showed a significantly greater frequency of systems already in operation. A majority of the institutions reported that their information retrieval systems run both on-line and batch requests and can handle scheduled as well as unanticipated reports. Most information retrieval systems also require the assistance of a professional programmer and do not have the capability to retrieve historical or diverse information as easily as current operating information from within a single information area.

Almost all of the responding CBMIS institutions indicated that administrative policies and data processing procedures exist to insure data security within the CBMIS data base. A majority of schools also indicated that software security systems were in use while only a few institutions reported that hardware security features were part of their CBMIS.

Of the 296 institutions reporting CBMIS activity, nearly half indicated that all four components (integrated data base, commonly defined data elements, generalized information retrieval system, and data security techniques) were included in their CBMIS. An integrated data base and commonly defined data elements were mentioned most frequently.

The use of commercial software products to support CBMIS development appeared to be limited. IBM's *Information Management System* (IMS) was the most frequently mentioned data management system while

Informatic's *MARK IV File Management System* was the most often mentioned retrieval system.

## IMPACT OF WICHE-NCHEMS

The impact of WICHE-NCHEMS on CBMIS development was considerable. Although only a small percentage of the respondent institutions participated on NCHEMS task forces or attended implementation conferences, attendance at NCHEMS seminars and subscription to NCHEMS publications was reported by a large percentage of the respondents, although public institutions with large enrollments tended to be the most influenced by WICHE-NCHEMS products. In CBMIS data bases the Resource Requirements Prediction Model (RRPM) and NCHEMS data element definition standards were used heavily. Finally, when asked to assess the impact of WICHE-NCHEMS upon the development of their CBMIS, respondents reported an overall positive influence, although private institutions appeared somewhat less positively impacted by NCHEMS activities than public schools.

## CBMIS IMPACT ON UNIVERSITY ADMINISTRATION

The use of CBMIS in nearly half the institutions reporting was accompanied by some increase in the centralization of administrative decision making. A large majority of respondents also indicated that decisions which reflect objective management considerations have increased in comparison to those which reflect political considerations since the use of CBMIS began.

Organizationally, it appears that the introduction of CBMIS has had little effect upon the number of levels in the administrative hierarchy and has not affected administrative support staffing (Business Office, Registrar, etc.) at most institutions. However, CBMIS implementation has resulted in increases in the size of data processing and institutional research/planning staffs, and has resulted in overall administrative staff increases and increases in the number of administrators with quantitative or computer background.

In response to a request for her/his assessment of the overall impact which CBMIS is having or will have upon her/his institution, most respondents mentioned the ability to make better management decisions through the provision of accurate and readily accessible information. Emphasis was also placed upon expected improvements in institutional planning, resource allocation and multi-campus management. Although a number of institutions described difficulties which they were having in developing their CBMIS, most respondents indicated positive expectations. Perhaps the most supportive of all the comments was made by one respondent who described the impact which CBMIS has had upon his institution this way: "It's survival!"

**Figure 1. Status of CBMIS Development**

| | N | % |
|---|---|---|
| No | | |
| No Plans to Develop | 31 | 7.2 |
| Undecided | 27 | 6.3 |
| Intend to Develop a Plan | 76 | 17.7 |
| Total No | 134 | 31.2 |
| Yes | | |
| Presently Planning | 121 | 28.1 |
| In Partial Operation | 172 | 40.0 |
| In Full Operation | 3 | 0.7 |
| Total Yes | 296 | 68.8 |

Figure 2. Contributions to CBMIS Planning/ Service Received from CBMIS-Rankings

| | Contribution | | Service | |
|---|---|---|---|---|
| *General Administrative Officers* | 2 | (1230) | 2 | (1502) |
| *Administrative Support Officers* | 1 | (1347) | 1 | (1546) |
| *Academic Administrators* | 3 | ( 890) | 3 | ( 890) |
| *Faculty* | 4 | ( 362) | 4 | ( 556) |
| *Students* | 5 | ( 178) | 5 | ( 397) |

Figure 3. Combinational Responses CBMIS Components

| N | % | Integrated Data Base | Common Data Elements | Information Retrieval System | Data Security (Software/ Hardware) |
|---|---|---|---|---|---|
| 140 | 47 | X | X | X | X |
| 87 | 29 | X | X | X | |
| 18 | 6 | X | X | | X |
| 18 | 6 | X | X | | |
| 263 | 88 | | | | |

Figure 4. Respondent Rating

| | Not At All | 1 | 2 | 3 | 4 | 5 | Heavily |
|---|---|---|---|---|---|---|---|
| Public | | 12* | 15 | 31 | 23 | 19 | |
| Private | | 13 | 30 | 13 | 24 | 20 | |
| All | | 12 | 17 | 28 | 23 | 20 | |

*Percentage of Institutions

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Figure 5. CBMIS Impact on Decision Making

| | % Increased | % Unchanged | % Decreased |
|---|---|---|---|
| *Centralized Decision-Making by Administration* | 41 | 51 | 8 |
| *Managerial vs Political Decisions* | 70 | 29 | 1 |
| *Faculty Role in Decision Making* | 24 | 75 | 1 |
| *Student Role in Decision Making* | 13 | 86 | 1 |

Figure 6. CBMIS Impact on Organization

| | % Increased | % Unchanged | % Decreased |
|---|---|---|---|
| *Number of Administrative Levels* | 7 | 85 | 8 |
| *Size of I. R. or Planning Staff* | 34 | 62 | 4 |
| *Size of ADP or MIS Staff* | 52 | 44 | 4 |
| *Size of Support Staff* | 8 | 76 | 16 |
| *Size Total Administrative Staff* | 20 | 66 | 14 |
| *Number of Administrators with Quantitative or Computer Background* | 47 | 52 | 1 |

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Figure 7. Responsibility for CBMIS Design and Implementation

| | Design | Implementation |
|---|---|---|
| *Data Processing* | 53% | 63% |
| *Institutional Research* | 23% | 19% |
| *Committee or Task Force* | 12% | 10% |
| *Administration, Finance or Business* | 5% | 5% |
| *External Group* | 3% | 0% |
| *Other* | 4% | 3% |
| | [N=293] | [N=286] |

# Chapter 12

## Once the Crunch Comes, What Goes First?

**by Lattie F. Coor**

To those who rode the ebullient financial crests of the campus of the 1960's, the stringencies of the 1970's seem to offer one shock after another: first institutions cut back on window washing and the grounds crew; then they got into the sea of secretaries and administrative assistants; and valiently they turned to the fat thicket of academic programs and whacked away at those unfilled faculty positions salted away for a rainy day. However, that obviously wasn't enough, even for openers, and as today and most certainly tomorrow, the academic administrator is facing the tough and usually painful decisions about really whittling away on academic programs, with many facing the imperative of even making a raid on the library's budget.

Certainly in all of this, some things are sacred, like the fund for receptions at the President's house, the subsidy for the faculty club, and unlimited support for the insatiable but essential computer center. Yet when push comes to shove, its obvious that even the sacred can fall as noted by the title of this paper. It's not *"if"* the crunch comes, what goes, but *"when"* the crunch comes, what goes *"first"*.

It is important in facing the challenge of sizing up the computer when an institution takes a hard look at its institutional priorities, to set up a frame of reference that will encourage presidents and academic and finance vice presidents to ask the right questions about the role of the computer service as stacked up against other priorities. Such an evaluation will also help computer center directors isolate the issues that will give them the strongest case for getting their best foot forward in the brisk foot race for resources.

This paper speaks to the array of services from the computer that should be isolated and examined in analyzing the computer service and its worth to the insitution, and suggests some questions the principle institutional decision makers should feel confident they have answered before perfecting a judgment on the computer service's budget. Some candidates for cost reduction *within* the computer center that might *go first* when the crunch comes are also suggested.

## A TYPOLOGY FOR ASSESSING THE COMPUTER SYSTEM

When resource allocations are to be made, it is wrong to try to assess the computer service as a lump. Some aspects of the service are more important than others, over time their relative importance to the institution may shift. One must ask "computing service for what?", much as one must ask "faculty density or strength for what?", with the success of the answer dependent on the clarity and precision of the analytical typology.

One can break campus computer service into four categories for analysis: research; instruction; clerical administrative data processing; management analytical capacity. Others may find a way to divide the service that better suits their taste, but a key first step is to develop a functional breakdown.

*Research.* In assessing the importance of the computer service to research, there are some immediate indicators that leap forward: the amount of sponsored research, and the proportion of the services budget it bears. Obviously a research reliant computer budget engages in fake economies if the cutback in service brings a roughly equal or greater loss of income. However, one must also ask how important the service is in providing non-supported research time to faculty and students. For some institutions, research access for non-supported faculty and students is an essential part of the educational milieu. In other settings, it might play a less prominent role.

Of importance in assessing the service against long-range goals, is research capacity for future institutional aspirations. Unused capacity now may be essential to the plans for reserach growth in the years ahead and, if so, simply must be fitted into the equation.

*Instruction.* The use of the computer as an essential tool in the educational program varies from institution to institution. For some, the service plays an active role in computer assisted instruction. For others, it is simply essential as a service permitting students to interact with the computer as part of their training in basic literacy.

However, all institutions must be very self-conscious about the relative ranking of the computer as teacher as it sizes up its whole kit of instructional resources.

*Clerical administrative data processing.* No one is proposing a return to the green eye shades and quill pens for a financial reporting systems, but all should cast a careful eye on how much ADP is the right amount. Often one overbuilds in some parts of ADP and underbuilds in others. The ADP function lends itself to a hard-nosed and precise analysis by contemporary management analysis, and it must be subjected to such.

*Management analytical capacity.* John Kemeny, President of Dartmouth and a mathematician, remarked in a fascinating article entitled "What Mathematics Every College President Should Know," that when he was a faculty member he thought the administration was hiding data. When he became President, he discovered they didn't have it. This situation, sadly, is true, and although colleges are building increasingly effective management information systems, they still have a long way to go to gain mastery over planning the future of a modern college or university effectively. It is a very complex task, and it is essential to have the analytical capability to discharge our responsibility for intelligent planning and for effective management.

In many cases neither the central administration, the faculty computer committee nor computer center director have paid particular attention to this aspect of the computer center's worth in setting institutional priorities. The issue ought to be a central one in sizing up the computer service, for here, as in no other area of the service, one can be penny wise and pound foolish.

A recent experience at Washington University is an example. Tuition income missed the estimate for 1973 by almost $900,000. Everything seemed in order until the fall semester tuition receipts were tallied: estimates were right on target on the size of our entering freshman class, and the number of new transfer applicants, so the poor estimate of tuition receipts was particularly puzzling. Painstaking and laborious analysis showed, after the fact, that the short fall was the result of a calculus of small factors: an increase in early completion; impact of a leave of absence policy; and so on. No one factor had stood out in the crude hand crank system of analysis which had been used for student flow analysis. But in the aggregate these discrete factors were enormously significant, and could have been detected by a more sophisticated data intensive system in time to take corrective action. Of course Washington University has redefined the data system so that the administration won't be caught off guard in this way again.

As a guide to sizing up the computer service as a part of management analytical capacity, six categories for attention may be useful: financial information systems; student data systems; personnel and payroll; academic resources; physical resources; and research management.

One might ask what kind of analytical capacity an institution needs in each of these areas, and then ask to what extent that capacity is provided by the computer center. On a ten point scale (one being low, ten being high) in terms of the analytic capacity of the data system on each of the six categories listed above, staff at Washington University rated the institution at point six in financial information systems and from zero to four in all other categories. The critical question then is, "Is this a sufficiently well developed analytical capacity for the institution's management and planning purposes?" That question must be faced and answered in assessing the computer center's place in the institutions priorities.

## COST REDUCTIONS WITHIN COMPUTER SERVICE

Five items can be considered as possible candidates for cost reduction within a campus computing budget.

- Examine all interactive computing capacity with an eye to eliminating unnecessary or little used units.
- Consider cost trade-offs of the big machines versus the small ones.
- The clerical ADP system, once built, tends to be added to, but seldom reassessed from the ground up. Reductions can take place in many instances without seriously impairing function.
- Evaluation of the various services provided by computer center staff could lead to reasoned reduction.
- Hardware a half-generation behind the cutting edge still can satisfy all the demands of most computer centers and costs a good deal less than the stuff that's hot off the press. Some real savings may be possible here.

Obviously all of these points, cannot be advocated simultaneously. Nor should any be used as a blanket item. The array of services should be carefully *tailored* to each institutions needs, as assessed regularly in conjunction with overall institutional objectives. The process should be a self-conscious one and a reasoned one. Hopefully these indicators will help in that process of analysis.

# The Financial Crunch and Computing at the Liberal Arts College

by Richard B. Hoffman

This paper addresses the role of computing at a small institution, how that role is affected now by the financial crunch facing the small liberal arts college, and what the future of computing seems to be at such a college.

## A MODEL COLLEGE

A model of such an institution may be useful for the purpose of discussion. Assume that the model college has a tuition-paying student body of 1750, a tuition cost of $2700 for 1973-74, and a room and board expense of about $1300.

The operating description of the institution might look like that shown in Figure 1.

In addition to the educational and general budget, the college has an auxiliary enterprises budget including dormitories, food services, and a book store with income and expenses of about 1.5 million. Excluding auxiliary enterprises, the college looks forward to increases in income and expense as shown in Figure 2 if no changes in program are anticipated. Several assumptions have been made to predict the total additional income and expense for the model college in 1974-75. First, a tuition increase of $140 (average reported by the Chronicle of $138) for 1974-75 is projected. Second, total compensation in 1973-74 was about 60% of the

**Figure 1. 1973-74 Statement of Operations**

| | |
|---|---|
| Income | |
| Tuition and Fees | 4,725,000 |
| Endowment | 525,000 |
| Gifts | 475,000 |
| Other Misc. | 90,000 |
| | 5,815,000 |
| Expenses | |
| General Administrative | 500,000 |
| General Institutional | 600,000 |
| Student Services | 400,000 |
| Instructional | 2,200,000 |
| Library | 300,000 |
| Organized Activities | 225,000 |
| Physical Plant | 750,000 |
| Public Service | 240,000 |
| Student Aid | 600,000 |
| | 5,815,000 |

educational and general budget. Although some of the costs are fixed, the category "other" includes fuel oil, utilities, supplies, and so on, which makes an inflationary rate of 4.5% not unreasonably high and perhaps low. Finally, the AAUP report of committee Z indicates average salary increases, depending upon rank, of 4.5 percent to 6.3 percent for private category II B institutions in 1972-73. The assumed increase of 5.5% for 1974-75 is certainly not high for a quality private institution. Very crudely, then, the essence of the financial crunch is illustrated by this model. Costs for maintaining program increase more rapidly than the

**Figure 2. 1974-75 Anticipated Additional Income and Expense**

| | |
|---|---|
| Income | |
| Tuition | $245,000 |
| Endowment/Gifts | 40,000 |
| | $285,000 |
| Expense | |
| Compensation (5.5%) | 192,500 |
| Other (4.5%) | 104,175 |
| | $296,675 |

institution's ability to increase income unless the institution is particularly careful and skillful in its management of resources.

One must also review the costs of a computer center meeting academic and administrative data processing needs. An adequate center might include a 16-port time-sharing machine with BASIC and FORTRAN language capabilities and a small, modern data processing machine. Some auxiliary equipment would be needed such as remote terminals, keypunches, etc. In staffing one might include an academic advisor, a data processing systems analyst, computer operator, and two keypunch operators (too many on some days, too few on others). Including supplies, a yearly expenditure is necessary on the order of $110,000 not including floor space, utilities, and administrative overhead.

Now the relationship between computing and the financial situation of the college crystallizes; the operating budget of an adequate center for a small institution is equivalent to about 38% of its new income.

Shift gears for a moment and think about computing at such an institution. Unless that institution has an unusually effective academic computing program in operation, relatively few of the students are actively utilizing the computer, and, very likely, only a handful of faculty are really interested in computing. Thus an institution facing possible cutbacks in staff, or at least a redistribution of staff, will find the academic computing facility to be highly visible when constituencies seek alternative ways to reduce expenditures.

The situation in data processing is rather different since many such institutions presently have little in the way of effective administrative computer applications. Clearly, a strong case for such applications must be made before increases to the administrative budget base of $50,000 to $60,000 can be seriously contemplated when academic expenditures are being held constant or reduced. One particular difficulty is that there is no basis for claiming that savings will result when administrative data processing is instituted, for there is much evidence to contradict that claim, and administrative officers tend to hold any advisor suspect who begins by making that claim.

Within the operations framework, computing is a drain on resources, and it is difficult, probably impossible, to build a financial case for computing in the short term (even neglecting start-up costs) at a small liberal arts college. However, for several reasons the matter can't end here.

## THE CASE FOR COMPUTING

From an academic point of view, a student graduating from a liberal arts college with no "hands-on" computer contact has received a defective education. The impact of computers on modern society has been so great, so important, and so wide in scope, that all areas of intellectual activity have been affected. Although it is utopian to expect all colleges to institute a "hands-on" computing distribution requirement, those institutions without some opportunities for academic computing will soon find this to be a strong negative influence on admissions and the recruiting of talented new faculty.

In the administrative area, there is a need for data processing, not so much because the computer is necessary for record keeping, but because data files must be machine readable in order that the institution can come to know itself in a much more sophisticated way than in the past.

Without an endowment large enough to protect it against planning errors, the private college will not survive unless the officers and trustees understand well the patterns of expenses and income, the patterns of student flow and impact, the patterns and dynamics of staffing, the trends in admissions, and the support and giving patterns of alumni, friends, and foundations. It is in the analysis of these areas that the use of the computer is critical in providing those summary reports essential to understanding the institution. Budget projection models permit one to investigate the longer term implications of budget decisions. Tenure and promotion projection models provide for the testing of the impact of personnel practices and policies upon the faculty profile. Student flow matrices permit careful attention to the distribution of the students in the curriculum, cost/enrollment and cost/major analyses. Faculty load reports provide a basis for equalization of work loads across departments.

Finally, if college leaders are to be convinced that computing resources are important to the College's future, care must be taken in making that case. For a small institution academic computing resources are not "free". It may well be that the small college cannot afford to support its own academic computer and that the best avenue to follow is the purchase of academic computing resources from another institution, in which case its cost will be immediately apparent. Most arguments following the "free resource" idea are based upon the notion that there is enough of that resource for everyone. The small institution likely cannot afford that, and such arguments are not going to convince the general officers of a college to invest in a computer. A careful curricular argument must be made showing how the computer fits into the academic program if limited resources are to be allocated for such reasources. General arguments that computers are nice to have are no longer adequate under the circumstances.

To make effective use of the computer as a management tool the general officers of an institution must understand what the computer does. They must have some understanding of the meaning of computer generated reports. They must have some schematic understanding of the simulation models: how they work; what they say; and what assumptions are involved. If these conditions are not satisfied, computer-oriented management capabilities are not likely to be effectively used. In particular, until the limitations of models and computer generated management information are understood, there is no reason to expect that computer model driven management will be of any higher quality than management based on incomplete information. EDUCOM's Seminar's for Presidents did provide opportunities for general officers to gain some experience and familiarity with computers and their use in 1971 and 1972.

In short, arguments supporting the availability of computer resources at the small institution must be of sufficient quality to win the argument with competing needs for the limited financial resources of the institution. If these needs cannot be effectively articulated, the computing resources will probably not be effectively utilized, in which case it is best that other needs be met until such time as effective articulation occurs.

## THE FRANKLIN AND MARSHALL CASE

Computing at Franklin and Marshall College began with participation in the computer consortium MERC, a computer consortium that did not, in its time, meet the objectives for which it was created.

MERC made all the classical errors. A small group of institutions obtained a medium-sized computer with the hope that they could obtain substantial computing capabilities with a minimum investment of their own resources. They hoped to make up the difference by selling left-over resources to non-member users. A large experienced staff was assembled, but unfortunately the expertise did not match the real needs. There was also no central authority to insure proper financial and policy management of the center. The hardware and software was new and, as occasionally happens, was not capable of meeting original levels of performance. In short, the computer could not support the number of users necessary to the financial viability of the center at the rate users were willing to pay. Marketing hunches turned out to be in error. There were not large numbers of users begging for time-sharing computing resources. Actually, there was a market for computing *services*, but, by the time this was understood, MERC had no funds remaining to support the center while applications were developed. The final blow was the financial crunch impacting the member institutions in the late 1960's.

Since the hardware belonged to Franklin and Marshall College, the institution was forced to take the initiative and reorganize the data center outside MERC or lose the computer.

Choosing to turn the operation of the center to a facilities management organization, by contract, the officers agreed upon a level of support the college needed and could afford. The facilities management took over all responsibilities associated with the staffing and operation of the center (including the responsibility for its financial stability) in return for which it obtained the right to use the remaining computing resources to sell either as computing time or in the form of computing applications and services.

Within this structure the college is beginning to experience some success. The college has computing resources of a kind it couldn't otherwise afford, and other higher education institutions are buying computing capabilities from the center, but at a price more closely connected to the cost of providing those services. Interestingly, the Franklin and Marshall Computing Center has become in Pennsylvania a model of how such a center can provide varied and quality services to public school systems at costs below those they can achieve themselves or get from other vendors.

Thus, by using a different management approach to deal with a crisis, Franklin and Marshall College has been able to meet many of the objectives set by MERC in a way not forseen a few years ago.

# University Management of Computing

**by William F. Lavery**

For the past five years Virginia Polytechnic Institute and State University has been placing major emphasis on both library and computational facilities and services. Computational facilities for educational purposes are as fundamental as a library. Because of this the officers have chosen to fund basic computing operations directly from "hard" funds, avoiding short term federal support.

VPISU is a comprehensive university enrolling over 16,000 graduate and undergraduate students in a wide variety of disciplines and programs. In addition, as a land grant institution, we have a commitment to major research and public service missions. These three primary missions (instruction, research and public service) along with the necessary administrative systems have literally forced the university into the major emphasis on computational facilities and services.

During this same period of time the financial crisis in higher education has been building nationally at a rapid pace. This paper therefore, has a two-fold purpose: to make a plea for management innovation on a broad scale in light of scarce resources; and to present a concept for allocating scarce computational resources as an example of management innovation.

## FINANCIAL CRISIS IN HIGHER EDUCATION

The extent and severity of the financial crisis in higher education today is indeed alarming. The National Association of State Universities and Land Grant Colleges has reported that many of its members have reported increases in their operating budgets of 10% or less while a 10% increase was determined to be the minimum average requirement for matching the effects of inflation and enrollment expansion.

In many instances where colleges and universities have continued to operate in the black, methods for sustaining financial solvency have included tuition increases and boosted rates of admissions rather than actual management improvement. There are strong indications that such approaches, where the student is asked to pay for disparities between productivity and costs, are nearing exhaustion. Therefore, it behooves university administrators to carefully plan for the future realizing small net increases in budgets for expansion and finding ways to achieve greater price performance.

Attempts to accomplish efficiency are best considered in three primary areas: cost-cutting procedures; income producing methods; and managerial actions. Obviously, there is considerable overlap within these three areas.

Most college administrators are all aware of several cost-cutting procedures, such as selective cuts, across-the-board cuts, consolidation, and the "sink or swim" approach. Such measures as deferment of maintenance, elimination of new programs, and faculty-staff cutbacks or freezes are frequently employed. However, some of these involve stop-gap methods which only erode overall educational quality in the long run.

One method of cost reduction receiving much attention in 1974 is to combine small related academic departments. Such an approach, it is argued, eliminates needless dual cost and administrative repitition. At VPISU where this approach was used to centralize several computer facilities it was most effective as well as more efficient.

Consortia represent another concept receiving increased scrutiny. Cost reductions can and do occur when contiguous colleges form alliances to offer courses, facilities, and services. VPISU is working on this possibility in Virginia in 1974 for data processing services. There are several arrangements which attest to the benefits of consortia.

From the standpoint of increased revenue, while tuition increases and the assessment of various fees remain valid and realistic practices, revenue from them alone will not solve the problem of the balanced budget. There are limits to higher tuition, especially in an era of the open door to education. Since the problem of boosting income sources may be expected to become even harder to solve, alternatives must be sought. Certainly colleges and universities cannot anticipate large additions from federal and state governments.

## MANAGEMENT INNOVATION IN HIGHER EDUCATION

Therefore, efficient management offers the promise of both the greatest frustration, as well as the best hope for survival. Certainly, institutions can anticipate an extended period of financial stringency. While funds may stabilize, university and college officers cannot expect demands upon them to do likewise. Accordingly, administrators must strive to do more, or at least as much, with less. This takes management innovation. Whether one likes it or not, it appears that continued financial solvency will necessitate adoption of approaches similar to methods employed by modern commercial management, including: a) careful analysis of the relationship between the utilization of resources and the accomplishment of goals; b) the quest for maximum economies with minimum sacrifices in quality of education, and c) the encouragement of rapid and flexible adaptation to changes in demands.

Scale considerations and organizational dynamics have led many organizations, including VPISU, to conclude that there are significant economies of scale in computing installations as well as desirable organizational efficiencies achieved by centralization of responsibility for the total computational function. Note that centralized responsibility does not necessarily mean one facility. Centralization hardly ever results in a single large-scale computer or the satisfaction of the total organizational data processing needs. Far more likely is the development of a central authority controlling a local network featuring multiple CPUs, I/O devices, and an array of local tele-processing terminal devices.

The goal is the allocation of scarce resources toward long-range objectives. At VPISU administrators have learned that such an approach requires major changes in the concept of managing the computational functions. One of these changes, was adjustment of the charging (cost center) system.

A computer services charging scheme implies a money management and distribution system; putting the allocation of scarce resources in the hands of the program decision maker. Other forms of computer credit systems have been devised, but the use of a dollar system remains prevalent, probably because it is more comprehensible to administrators who may or may not understand computer systems. Money managers are used to using a dollar form of money management in their operating and capital outlay budgets. To satisfy money managers in the administrative hierarchy, the distribution and control of computer services funds should conform as nearly as possible to the administrative hierarchy itself. The implication is that he who gives can also take away.

Computer services charging to be successful must be realistic, equitable, and imposed to recover cost rather than to arbitrarily discriminate service classes. As higher levels of management aggregation are reached, programs rather than administrative budgeting may become more attractive or rational. What is being accomplished is that decisions on priority use of a scarce resource is in the hands of the money manager in the same manner as decisions on hiring of faculty or purchasing equipment are. Charging removes the arbitrary constraints of job classes, time limits, core constraints, and the like. It imposes the alternative burden of money management on the user.

Experience at VPISU indicates that the user prefers the money management problem since it focuses his selling job on his administrative superior rather on those "unknowledgeables" in the computer center. At the same time, administrators welcome this approach.

From the standpoint of the computing center, computer services charging presents a confusing dichotomy. While gratified to be relieved of scheduling and resource allocations problems, center administrators are uneasy because efficiency of utilization of the computer resource is also removed from their direct control. Therefore, a high level of understanding and communication between center management and top management of the organization is essential. Top management must be convinced that something approaching 100% efficiency of computer resource usage does not imply maximum resource allocation to optimizing the organizational objective functions. Parallels between the use of the motor pool, office space, etc. must be drawn and understood. This mistique of 100% utilization must be dispelled or computer center management is confronted by unresolveable conflicts that will obviate the advantages of cost center operation.

Some form of a priority or service charge needs to be implemented to develop user acceptance of the cost center technique. For many users, turnaround time will be the most important resource they can purchase. Several alternatives, however, are available. Cost differentials can be associated with prime and non-prime shifts; or differentials may be given for purchase of job start or job finish times. Turnaround time then is not sold, but relative position in the job queue is purchased.

A cost center charging system as described here has been operational at the Virginia Tech Computing Center for four years. This system, SMART (Systems Management and Allocation of Resources Technique), has received gratifying user and management acceptance. Officers at VPISU are in the business of allocating scarce resources; whether it be computing resources, library resources, fuel, or personnel. They and administrators at other institutions are searching for new managerial techniques. SMART is one such technique which has proven itself to be of great value in the overall management picture.

# Chapter 13

## Funding Agencies: What Have They Done for You Lately?

### NSF Technological Innovation in Education

**by Erik D. McWilliams**

The Technological Innovation in Education (TIE) program of the National Science Foundation is empowered and funded essentially to ensure the existence and application of better and better instructional technology, for all levels of education. This mandate includes but is not restricted to computing technology; it does not include administrative data processing in the usual sense of the term.

The TIE program began some 5 or 6 years ago in the Office of Computing Activities, where it was appropriately known as the Computer Innovation in Education Program (CIE). The change of title occurred in 1973, following the transfer of the CIE Program to the Education Directorate of NSF.

TIE is one of four programs within the Foundation's Office of Experimental Projects and Programs. Generally speaking, TIE's responsibilities for educational technology extend through the proof of concept stage; another program in the office is concerned with restructuring educational environments, through the application of technology and other innovations. TIE therefore supports research, development, and field evaluation of promising hardware, software, and applications or courseware with a budget of roughly $7 million per year and a professional staff of five.

Before reporting on some of the most significant projects, it may be useful to state clearly what TIE *cannot* support any longer. The office cannot provide support designed solely to improve a single institution. Consideration must be given to supporting those projects with the greatest likelihood of proving useful to other institutions. Furthermore, TIE cannot, with $7 million support very many of the latter. It is necessary to concentrate modest resources upon a few projects that seem to offer significant promise for *many* schools.

TIE's most visible support is invested in the development and field-test of the PLATO and TICCIT systems of CAI. Because these systems and field-tests are quite complex (technologically and sociologically), NSF has contracted for a third-party evaluation of each, through the Educational Testing Service. The systems themselves have now been built. I expect that many of you have attended at least one PLATO demonstration. The instructional content and strategies are being programmed presently, in preparation for the field-tests which will commence in September of 1974. Some features of these projects are most pertinent to considerations of funding:

- Such projects are inherently complicated and costly; roughly half of the annual TIE budget is invested in the PLATO and TICCIT projects.
- Each of these projects depends upon thorough collaboration between a university and other educational institutions, with the universities providing educational services that seem to be largely unavailable to their clients otherwise.
- Support from NSF and others seems likely to produce a good deal of courseware suitable for many other universities; for example, a good deal of PLATO courseware already exists for physics, chemistry, foreign languages, and veterinary medicine, and a large group is now at work preparing courseware for medical student training. Several other universities are interested in obtaining PLATO terminals and service, to access this growing library of lessons for their own classes. (One major university has already committeed its own funds to enable it to install and operate its own PLATO system. Delivery is scheduled for September 1974.

TIE has also supported the development of other CAI languages and systems, including PLANIT, which is the only CAI system designed to operate on virtually any computing equipment. The purpose in investing in PLANIT beginning in 1968 was to enable universities to install and operate a rather powerful CAI system without major investments of capital or manpower. Purdue University is just completing a field-test of PLANIT, and design goals appear to have been met. PLANIT may be the only high quality, transportable system in existence. Some three or four dozen institutions have purchased the tape and are in the process of installing the system.

During FY 1973, TIE also continued to provide support for several experiments designed to enable universities and colleges to improve instructional computing. One of these, CONDUIT, is designed to determine the obstacles, opportunities, and requirements for transporting computer-based curricular materials between various educational institutions. Universities at Oregon State, North Carolina, Dartmouth, Iowa, and Texas operate regional computing networks, which collaborate with a central CONDUIT staff to select and transport materials. This experiment is being evaluated by an independent organization, HumRRO, of Alexandria, Virginia. The study is by no means complete, but viable mechanisms for ensuring transportable programs have been uncovered, and will be reported within a year. (Incidentally, CONDUIT is presently testing PLANIT, as well as other software designed to be transportable.)

A second experimental project known as COMPUTe is designed to develop and field-test another model for introducing instructional computing into the curriculum. Individual faculty members are encouraged to submit to the grantee a proposal for developing teachers' guides and minitextbooks containing instructional computing examples and exercises. After a suitable competitive review, some number of proposing faculty are invited to spend a summer on-site, preparing their programs and minitexts, before returning to their own institutions for field use and subsequent refinement of their materials. Quite a number of minitexts have been developed, and it seems likely that they will be published and sold commercially, so that any or all of them could receive truly widespread use.

TIE has also invested in a system of computer-based career guidance and information (SIGI) that looks very promising, following first field use in New Jersey. Students liked it very much, and demonstrated significantly better information and skills required for making career decisions. Although the present system was designed and constructed for community colleges, plans are being considered for an extension to four-year colleges.

Through TIE, NSF has also invested in other projects of research and development for educational improvement, including a project to exploit the use of audio input and output for computer-based systems, and for the development and field-test of various other systems, devices, and programming languages for improving education at one level or another. For example, consideration is being given for a proposal for an extensive field-test of the delivery of computer-based educational services into the home, using TICCIT and cable television technology. In addition, several studies of factors affecting instructional computing, and an annual conference where faculty can share their experiences in computer-based instruction have been supported.

## "WHAT HAVE WE DONE FOR YOU LATELY?"

While TIE is benefitting education viewed in the large, by making available systems and insights that seem unlikely to be available as soon otherwise, these factors probably make the planning process more difficult. Some college and university administrators may even be thinking "Stop helping me already!". The Foundation would like to be of more service than is presently possible. However, the Education Directorate's budget is quite small; only $60 million in FY 1975, with TIE's budget pegged at $6.0 million (down from $8.4 million in FY 1972). These modest resources certainly constrain plans and ambitions, but any serious recommendations or concerns will be carefully considered.

# Ask Not What Funding Agencies Can Do For You . . .

### by Glenn R. Ingram

## BACKGROUND ON NIE

One fundamental fact about the National Institute of Education is its age: it is just over a year and a half old. In the legislation that created it, NIE was given the mandate "to seek to improve education...in the United States." No matter what the resources of money and people, no agency will wrap up an assignment like that in a year and a half. NIE is engaged in a long-term enterprise, where the lamp of history doesn't perfectly illuminate the path of the future.

Administratively, NIE is part of the Department of Health, Education, and Welfare, and its Director, Dr. Thomas K. Glennan, reports to the Assistant Secretary of HEW for Education. The Director is advised by, and obtains approval from, the National Council for Educational Research (NCER) which consists of 15 members appointed by the President and approved by the Senate. In the steady state, each member of NCER will be appointed for a three-year term.

When the agency was created, a number of projects were transferred to it from the Office of Education and the Office of Economic Opportunity. NIE has moved deliberately in planning and organization, and in recent months, five priority areas have been defined, with approval of the NCER. One of the priority areas, productivity, is lodged in the office of the Productivity and Technology Program. Headed by Arthur Melmed, formerly of the National Science Foundation, it is one manifestation of the agency's concern for one of the missions in the legislative charter: to strengthen the scientific and technological foundations of education. Although other groups of NIE have, or will have, some involvement with computing, the Productivity and Technology Program will be the primary interface with computer-related projects.

This Program has, to date, been identified primarily with a few major projects that have each had a long gestation period. In three satellite projects in Alaska, the Rocky Mountain region, and the Appalachian region, a new communications technology will be used for new educational approaches. Other projects include: SUN (State University of Nebraska) an "open university" which is concerned with technological approaches to adult education; the Marketable Pre-School Education Project at the Appalachian Educational Lab; and the Computer Technology Project at the Northwest Regional Educational Lab. In addition to the technological aspects, the program has an economic facet: the productivity of educational institutions. It seems clear that the costs and the productivity of all educational institutions are coming under closer scrutiny, so the name of the NIE Productivity and Technology Program has significance. The general objective is to explore ways in which the application of technology can enhance the productivity of educational institutions. This doesn't imply a narrowness in the understanding of productivity, but it does provide a framework for the role of technology. The program is concerned with the application of a variety of technologies in education. To complete the picture, and to give some perspective, the NIE budget for its first year, FY 1972-73, was about $110 million; in the 1973-74 fiscal year it is $75 million.

## WE'VE ALL GOT PROBLEMS

With those numbers, one can understand that university computing doesn't stand alone in its concern about funds and priorities. It can be assumed that both universities and funding agencies are interested in the other's problems and well-being. In the context of a conference intended to explore the position of computing in institutional priorities, a scriptural quote seems appropriate: "A feast is made for laughter, wine maketh merry: but money answereth all things." (Ecclesiastes 10:19). Despite the authority of a Biblical passage, it seems in order to question whether university computing has unique financial problems, and whether some problems would be solved by more money. Consider four questions:

*Given that most colleges and universities have financial problems, does computing present an identifiably distinct problem?* A few years ago, computing was breaking into the budget in a major way. It was competing with established demands, and was fortunate that overall budgets were moving up rather sharply. Even in a tight period, computing is in an enviable position within an institution: it should enjoy the strong support of a large number of departments after they've solved their own problems. Of course, the situation will vary from one institution to another, but many would say that computing has had time to establish its position in the priority line. If this isn't true, there must be a more vivid presentation of the case. It is clear that the Pierce Report didn't persuade everyone.

*The NIE is interested in improving education: what does computing do to improve education?* It isn't enough to gather at various meetings and convince each other. If computing has had, or will have, a significant effect in improving education, the supporting evidence hasn't been overwhelming apparently. By contrast, nearly everyone accepts, as established fact, that computing is essential to research. If the answer to the first question is "Yes", how much of the problem is due to research, how much to instruction, and can a stronger case be made for instructional use?

*What is the current, short-range, and ultimate role of computer networks?* There are various models of networks, and honest questions about what they can accomplish, and for whom. Some faculty convince each other that the trend in minis simply reinforces the arguments for regional networks, but some potential participants may feel differently. Private and public institutions may have different reflexes about some kinds of networks, at least in part because of the growing importance of state czars or boards in controlling computers. There is also the law of increasing inertia which describes money's reluctance to cross state lines. In an arena where the computer gladiators don't present a united front on issues of regional, statewide, national, and discipline-oriented networks, it seems reasonable to assume that others will take note.

*If there are questions about the position of computing in institutional priorities, there are also questions about priorities within educational computing. What are the relative roles of: CAI and CMI traditional uses; and minis, maxis and programmable calculators?* This question is large enough to merit a session of its own. No one responsible for computing in a university can avoid these issues, nor can funding agencies, even though answers are far from clear. This may come back to the first question about finances: there seems to be a slow rate of growth of high quality software for instruction; would money answer this problem? The point of the questions and the comments is that believers in computing have some ordering to do in their own house. Then there is still a need to convince others of the righteousness of the cause.

## NIE DIRECTORS

Computers have a substantial role to play in education. To the Productivity and Technology program they represent part of an overall exploration of applications of advanced technology in education, and certainly are intimately linked with communications technology. The program is interested in software systems, artificial intelligence and other areas of computer science as they can improve instructional uses. It is worth noting that another program in NIE provides support for NCHEMS, so the agency is involved in administrative uses of the computer also. To date, the institute has had no involvement with networks, and a future role isn't obvious, but staff want to stay abreast of developments and remain open to possibilities.

Finally, what about CAI, CMI, and traditional uses? Given NSF support of two major CAI projects, it seems unlikely that there will be increased federal spending in that direction. NIE plans to support a small CMI workshop/conference in the fall of 1974 to examine and report on the short range potential of CMI. Traditional uses of computing in higher education is by no means a well that has gone dry. Of course, the term traditional covers a lot of ground, and any thorough discussion would require more careful discussion of problem solving, use of canned programs, simulation and so on. A lot of money, institutional as well as federal and private, has gone into this area, and yet, the situation isn't as tidy as it might be. Are educational users of computers at a stage where an additional modest investment could create substantial benefits for higher education, or is this a long term development? These questions and comments should present a picture of a group that has a strong interest in computing, but as yet, no fixed programs.

The programs that evolve will be consistent with the objectives of the Productivity and Technology Program, and with the mission of NIE. Within those constraints, staff welcome input and ideas from any source. As mentioned earlier, the office is in the process of formulating program guidelines, but is always ready to discuss a prospectus for a project. One can, of course, submit an unsolicited proposal, but, in general, it's a good idea to send in a brief description of the project or to stop by to discuss plans before preparing a formal proposal. In addition, the Welcome mat is always out at NIE. If faculty or administration want to talk things over, they don't even have to ask for money.

# NSF Division of Computer Research

**by D. Don Aufenkamp**

The Division of Computer Research supports basic research in computer science and engineering, computer applications in research, and research studies on the technological aspects of society's use of computers. The objective is to gain an understanding of the basic principles underlying computing and discover procedures for applying those principles. In DCR projects emphasis is placed on the more fundamental aspects of computer science and engineering, but support is provided, too, for the research required to make the computer more responsive to requirements of the other scientific disciplines.

These thrusts are of relatively recent origin in the evolution of National Science Foundation programs. In fact, prior to March 1974 DCR was known as the Office of Computing Activities, and until just a few months earlier the office was within the Directorate for National and International Programs.

The year 1967 is approximately the time at which the Office of Computing Activities was formed, although grants for computer-related activities were made for some years prior to that. Initially the Institutional Computing Services program overshadowed OCA activities and the history of that lingers on although the program was terminated in 1970. When Computer Innovation in Education emerged as a major thrust, it seemed more appropriate to make that component a part of the NSF Education Directorate. Computer Science and Engineering (CSE), which has been developing as a key program thrust over many years, is certainly at the heart of the work of the division and Computer Applications in Research represents a more recent thrust of the division. At its center are efforts to transform new results in computer science into advanced research methodology for the disciplines: chemistry, economics, biology, and so on. Special Projects is also of recent origin in its present form although much of the early work in computer innovation in education was supported from an organizational unit also called Special Projects. Currently this section is focused on encouraging the development of new fields of computer science research which are responsive to problems and opportunities arising from the widespread use of the computer.

Support for the computer-related activities also appears in many other places within NSF: the Division of Engineering; the Office of Science Information Service; and the disciplines.

Substantive aspects of a given program within DCR are best described by a summary of awards made in 1973 which has been published for the first time in 1974. Copies are available from the division or from the NSF Office of Public Information.

## DCR FUNDING 1973

Within CSE are three programs, all handled very much in the tradition of the Foundation's research project programs. Approximately 40% of the funding of CSE is allocated to topics in software and programming systems with the balance being split roughly between theoretical computer science and computer system design.

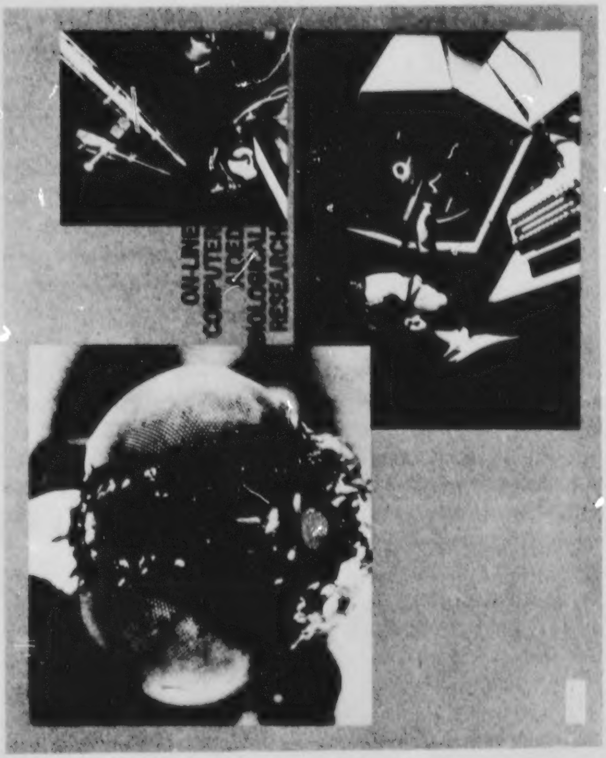
Computer Applications in Research are characterized by:

- a foundation in computer science;
- an understanding of science research needs;
- a transfer of advances among disciplines; and
- coordination with other NSF programs and with other organizations.

There are currently three thrusts in Computer Applications in Research. At the center of Computer Applications in Research is the Techniques and Systems Program which places a strong emphasis on coupling computers to the conduct of research.

On-line biological research, sponsored, in part, by NSF is being carried on at CalTech and is leading to advances in the conduct of research which would be extremely difficult if not impossible to achieve without the advent of computer-based systems. Figure 1 attempts to capture some of the spirit of that program. Much of the effort to date in the Software Quality Research Program centers on mathematical and statistical software. One of the projects currently receiving support is the NATS project (National Effort to Test Software) in which Argonne National Laboratory in cooperation with eight other institutions including the University of

Figure 1.


ON-LINE
COMPUTER
AIDED
BIOLOGICAL
RESEARCH

This photograph is included in this volume through the courtesy of Caltech.

Toronto is addressing problems of providing researchers with accurate, thoroughly-tested and well-documented mathematical software.

One of the more interesting activities in Computer Applications in Research is the Networking for Science Program. A recently released book, *Networks for Research and Education* outlines the principal findings of the participants in Seminar series conducted by EDUCOM in 1972-73. Networking does represent a new mode of access to information, data and computation. While technology is important, the principal obstacles to be overcome are primarily political, organizational and economic. A strong human organization is critical to success and it is often difficult to articulate exactly what is needed. The most important point of the book is not that networking in itself is a solution to the current problems in computing and information services, but it does represent a promising new vehicle for bringing about changes in user practices, institutional procedures and government policies. Funding for Special Projects has been modest to date and much of the work has taken the form of appropriate workshops and special studies to provide a perspective on the problems and to provide an indication of how Foundation resources could best be used. Special Projects is also the focus within the Division of Computer Research for efforts on questions dealing with energy-related research. One project now being considered is research on computer sciences techniques for improving the structural design and reducing uncertainty and error propagation in large computer-based energy policy models.

Figure 2 may give some perspective on total federal support of computer science and computer engineering research. Emphasis is on the core computer science and engineering activities such as those represented by NSF's CSE program.

**Figure 2. Federal Support of Computer Science & Computer Engineering Research (Thousands of Dollars)**

| Agency | FY 72 | FY 73 | FY 74 Estimates | FY 75 Est |
|---|---|---|---|---|
| AEC | 2,751 | 2,380 | 1,410 | |
| ARPA | 15,584 | 17,026 | 12,700 | 14,200 |
| Other DOD | 3,220 | 2,980 | 2,700 | |
| HEW | 3,660 | 2,920 | 2,800 | |
| NASA | 4,300 | 3,940 | 4,100 | |
| NSF/OCA | 8,400 | 6,500 | 5,800 | 6,500 |
| Totals | 37,915 | 35,746 | 33,810 | |

# PART IV

## HOW CAN COMPUTING SERVE INSTRUCTION?

# Chapter 14

## How Can Computing Serve Instruction?

**by Gerard P. Weeg**

The EDUCOM Spring 1974 Conference is intended to bring together, in more significant proportions than ever before, the computer professionals who are deeply involved in the daily operation of university computer facilities, and the university top level decision makers who set priorities and policies, some of which affect computing. Indeed, from the perspective of a computer center director, one feels that every university decision affects computing, since all university departments are competing for a very finite sum of dollars. It is important in a meeting like this to establish common meanings for the catch-phrases which the computer pros will be using, so that the decision makers and the computer pros will have the same concept in mind when certain words are used. Central to all that follows is the thesis that there are ways in which computing, augmented heavily by human planning, preparation, and then understanding and assimilation of the results, can support instruction.

### ADMINISTRATIVE DATA PROCESSING (ADP)

The administration of a university has but one function when considered in its essential form, and that is to facilitate the process of education. This is an immense task, one which most believe has grown so enormous that it could not be carried out without computing.

Some typical uses of the computer and its associated staff in aiding the administration to carry out its facilitation role are:

- *Admissions*
- *Registrar*
  Grade Reporting
  Class Lists
  Student Information Systems
  Graduation Requirements Checking
- *Finance*
  Billing
  Accounts Receivable and Payable
  Grant Accounting
  Financial Aid
  Endowment and Other Income
  Payroll
  Inventory
- *Faculty Data Base*
  Teaching Load
  Research Load
  Departmental and College Comparisons
- *Scheduling* of Students and Patients (for health-related colleges)

The computer is a mere tool in all these operations. For a successful ADP mission, an expert and sizeable staff is essential, which in turn interacts with great skill and understanding with the top level university authorities in setting up tasks, goals, deadlines, and criteria. A second ingredient is realistic planning. A third is adequate computer hardware (with care being taken to delegate to a computer only what is best performed by a computer). A four ingredient is adequate funding of the entire operation.

## DIRECT INSTRUCTIONAL SUPPORT

The use of computing in direct support of instruction is often a source of confusion to both administrators and computer pros alike. To clarify the situation one can view direct instructional support in two ways: by hardware mode and by functional mode. Analyzed by hardware mode, computing can be provided in two ways.

*Batch Processing* is typified by a central computer facility: accepting card decks from students and faculty; producing output listings on line printers; and functioning with uncertain time lapses between the submission of the card decks and the return of the results (turnaround).

*Interactive computing* is typified by the user's direct communication with the computer by means of typewriter like devices such as IBM selectric, teletype, or cathode ray tube devices. Each line of type is input to the computer as it is typed, and errors in a line are announced by the computer as soon as the line is input. The time taken for the computer to digest a line and be ready to accept another being on the order of two seconds or less.

When viewed by functional mode, however, computing falls into four categories:

*Problem Solving I* includes casual use of a computer to handle assignments which relate to a class.

*Problem Solving II* consists of intense use of computing to such an extent that a course has been redesigned to take advantage of computing. In this mode computing can be used to teach something more effectively than could be done in a traditional mode.

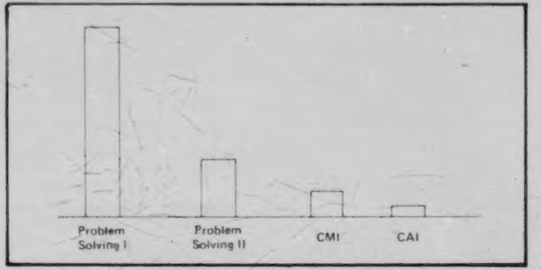
*Computer Managed Instruction (CMI)* is the use of computing together with carefully prepared diagnostic testing to determine on an individual basis where the understanding of certain course concepts has broken down. Often remedial work is suggested by the computer.

*Computer Assisted Instruction (CAI)* involves the use of computing as a tutor to replace an instructor in all or part of a course. The challenge is to determine those areas of instruction in which such a mode is at least as effective as traditional teaching.

It is the case, as one might suspect, that quite often these various functional modes slide into each other; sharp distinctions are difficult to make. What is certain, however, is that a vast amount of work has taken place in all modes.

Anyone who wants to start should read Karl Zinn's[1] report. Other publications show the extent to which computing has penetrated instruction: the 1970 World Conference of Computing in Instruction[2]; the four conferences on Computers in the Undergraduate Curricula[3]; and the first British Conference on Computing in Higher Education[4].

To place these various functional modes in perspective, the amount of actual productive work as it has appeared in classroom usage could probably be best described by the following bar graph.



Although the bulk of classroom use of computing is presently done in the Problem Solving I mode, immense efforts have also been devoted to Problem Solving II, CMI, and CAI. Indeed, the preponderance of effort is being spent there now and has been for a number of years. In these areas one should expect to see the most significant advances.

As with ADP use of computing, nothing magical takes place with computing in support of instruction. Once again, adequate hardware is needed; a strong forward looking computer center staff is needed; and some extremely gifted teachers and innovators are needed. Planning, objectives, and criteria are indispensable, and of course, funding is the *sine quo non.*

A little sermon illustrates the importance of computing in academe. Mankind has seen only a few occurrences which have been so momentous as to change the direction of civilization. Numbered among these must be:

- the creation of the written word, which allowed the thought expressed to survive its utterance;
- the creation of the printing press, making learning available to the masses; and
- the industrial revolution, which effectively expanded human muscle power, permitting people to do that which was formerly impossible.

To this list I suspect one must some day add the creation of the digital computer which is the first intellect extender. Here is a tool which allows people to decide which mental tasks should best be done by them, and which by machine. The astounding conclusion is that people are left with the creative tasks, the challenging and inspiring work, while the computer can handle the tedious, repetitious, and dreary tasks.

The extent to which computing has penetrated society can be estimated by observing the following statistics[5]. Computers do 99 percent of all clerical work in the U.S. today. In FY 73-74, $23 billion will be spent to install, operate, and maintain the 120,000 computers in the U.S. Some economists predict that by 1980 computing will be the world's single largest industry. Approximately 10,000 computers are in use in American schools today, ranging from elementary schools to graduate schools.

A primary role of education is the joining of the junior and senior scholars to review and understand the great events, thoughts, forces, and discoveries of the past and present so that these scholars can be prepared to adapt to, and hopefully, control their future. Clearly one such force is the computer. Each college graduate must possess some degree of computer literacy, which will be best attained by studying the role of computing in most courses which the student takes, rather than as a separate subject or unit of study.

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3. 1970, Iowa, CCUC/1; 1971, Dartmouth, CCUC/2; 1972, Atlanta, CCUC/3; 1973, Claremont, CCUC/4. CCUC/5 will be held in Pullman, Washington in June, 1975. All Proceedings are available from the University of Iowa Computer Center, LCM, Iowa City, Iowa 52242.

4. 1974 Conference of Computers in Higher Education, Lancaster University, 26-29 March 1974; Proceedings will be available from the National Computing Center, Ltd., Manchester, England.

5. *U.S. News and World Report,* Nov. 5, 1973, p. 46.

# Chapter 15

## Creating Instructional Material

### A Model for Creating and Publishing Instructional Material to Achieve Educational Change

**by A. Kent Morton**

## INTRODUCTION

A modest project with two major objectives, (Computer Oriented Materials Production for Undergraduate Teaching) is located at Dartmouth College and has been operating for the past three years with funds from the National Science Foundation. COMPUTe's principal objective is to effect educational change by providing high quality instructional material in support of undergraduate uses of computing. The publication and wide dissemination of some 30 texts and monographs, in a variety of subject areas, is a short-term goal. The second COMPUTe objective is to change the fundamental attitude of publishers towards computer-dependent instructional material. Most publishers shun involvement with so-called experimental curricula on the grounds that the market cannot justify the financial risk; adding computing to the mixture makes a publisher even more skeptical of the product's success.

COMPUTe has other objectives of varying importance: to establish incentives for talented teachers to engage in the development of such materials; to help reestablish the credibility of teaching and interest in teaching techniques as honorable pursuits (at the college level they have too long been subordinated to research, paper-writing, and consulting); and to accumulate some experience in what it takes to produce instructional material that, like a standard textbook, is useful to large audiences, rather than to the author and his students alone. COMPUTe seeks not to assist the creation of instructional material, but rather to assist in the production of materials in a form suitable for others to use. COMPUTe holds that the *creative* source for such material must be the active classroom teacher, and the COMPUTe project is a *medium* for making successful methodology available to others.

## WHY HAVE SUCH A PROJECT?

To answer this question one must consider a more basic question: what are the obstacles to the spread of computer uses in instruction? (Assume for the purposes of discussion that the spread of computer usage in instruction is a desirable goal.)

The final report of the EDUCOM study, *Factors Inhibiting the Use of Computers in Instruction*[1] states that "the problem which received the highest ratings in terms of importance in the entire questionnaire was...the lack of good, readily available computer-based materials." The next most important factors were judged to be lack of professional and economic incentives for development of such material, and lack of incentives for faculty to expend the necessary time and effort to modify or create alternative instructional materials.[2] COMPUTe is attempting to meet the demand for such material.

Another index of the level of interest in instructional applications of computing may be seen in the continuing strong interest in the annual series of conferences on computers in undergraduate curricula, sponsored by the National Science Foundation and various individual institutions. These conferences deal, however, in presentations of experiences, rather than offerings of saleable material that might be generally useful. COMPUTe displayed some of its material at last year's conference in Claremont, California, and the project objectives were met with considerable approval from conferees. It is also significant that during the past 2-1/2 years membership in the ACM Special Interest Group on Computer Uses in Education has almost doubled; it now stands at close to 1200 members. The *SIGCUE Bulletin* supplies: news items and reports about instructional computing projects in the United States and, occasionally, abroad; a bibliography of articles and other published materials; and a calendar of meetings and workshops. In short, there is no lack of interest in information about instructional applications, and there is a strong desire to see a variety of good materials, already used in the classroom from which teachers can choose.

## PHILOSOPHY

Writing, testing, documentation, and dissemination of computer programs has been of comparatively little interest to COMPUTe, primarily because we took the stance at the outset that moving programs to a new computer and supplying operational documentation is not a serious problem. The experiences of the CONDUIT Project, (See Chapter 11) bears this out. What is critical is pedagogical documentation. In other words what do you provide to a teacher inexperienced in this methodology in order to help her/him use this material in teaching?

Neither is COMPUTe interested in developing new strategies for using the computer in education. On the basis of observations and some of the indices mentioned above, COMPUTe has assumed that many good applications already exist, but need further support in order to document the classroom experience sufficiently well for others to take advantage of them.

Art Luehrmann, Director of COMPUTe, stated in a recent paper that, "at the university level educational change is almost always accomplished by the appearance of a new, commercially available textbook. Change happens when faculty members decide to adopt the new book instead of the old one. There is no reason to believe that widespread computer use will happen in any other way."[3] Over 200 papers have been presented at the four CCUC meetings sponsored by NSF; yet, by and large, an individual application rests with the originator and is not transmitted to colleagues even within an institution, let alone outside of it. There has evidently not been sufficient enthusiasm, in spite of the high level of interest, to promote widespread imitation of the applications discussed.

COMPUTe believes that there is a simple reason for this which stems from the tremendous investment of time and effort that a faculty member must make to develop instructional computer uses. One cannot reasonably expect that level of investment every time a course is given. On the other hand, in Luehrmann's words, "if teachers were able to get from their local textbook purveyor a few readable, pedagogically practical examples of course materials in their own disciplines, I believe we would see an enormous growth in educational computer use.[4] This is precisely the sort of condition COMPUTe is working to achieve.

## OPERATIONAL STRATEGY

On the basis of formal proposals submitted to COMPUTe and referred by others, six or seven people are selected to work on summer writing projects. These authors are invited to leave their home institutions and all the normal interruptions of their home and office routines in order to come to New Hampshire for periods ranging from 4 to 10 weeks. Each author so accepted is charged with writing as much of a monograph or textbook as possible while s/he is at Dartmouth and agreeing to see the project through to completion after s/he leaves. This generally takes some prodding from the staff once an author is again immersed in normal routines.

In return, the project provides up to two months salary directly to the author, partial travel and housing subsidies, and secretarial and editorial assistance as required to advance the writing project to completion. As an author finishes a draft of a chapter, a member of the staff types it into a computer file, and all subsequent changes, either in content or format, are made by modifying that original file using editorial features available on the computer system. Another system provides a formatted, paginated copy of the current state of any portion of the manuscript whenever desired, with the result that, even in a relatively short period of residence, an author can see drafts of work as it proceeds and improve it.

When an author finally completes his/her written work on the project, which is typically 6 months after leaving Dartmouth, although a few have actually completed their tasks before leaving, the staff can either produce multilith masters from which to make copies for immediate use on a small scale; or it can produce camera-ready copy using a carbon ribbon and have the product printed by photo-offset methods.

Much of the activity during the summer writing sessions is of an informal nature. Because it is stimulating for each author to be exposed to the work of the others, weekly get-togethers are scheduled during which each author discusses her or his work. Other conversations, many of them unknown to the staff, take place among the writers in the public terminal room, around the coffeepot, and in the corridors of the computation center where the staff is located. There is also an annual picnic for authors and their families. COMPUTe tries to create a pleasant atmosphere which will be conducive to creating a good product, and the project provides student programming assistance and portable terminals as necessary to each author.

## PUBLISHING PLANS

Over 100 publishers have been kept informed of work in progress since Summer 1972, when the first writing session began. Until the fall of 1973, strategy was to submit individual manuscripts to publishers as they expressed interest in them, with the intent of letting them bid on titles of interest. This approach was consistent with the belief that the market should determine which projects were commercially viable and which ones weren't. In spite of this initial review procedure and careful attempts to direct the course of a project in order to ensure a quality text, there were bound to be some products that just wouldn't sell well. Every commercial publisher has this experience.

However, there was a larger objective at stake. It became clear that this skimming technique would produce many diverse products which would virtually preclude drawing any accurate conclusions about the viability of the COMPUTe model as a means for producing computer based instructional material. COMPUTe is now committed to reaching an exclusive publishing agreement for the entire output of the project which should be in the neighborhood of 30 texts. Only in this way can a product identity be created which will match a given text with the model which produced it and make the educational community sufficiently aware of that model to assess its strengths and weaknesses.

## WHERE WE ARE NOW

After three years of funding, COMPUTe has 13 efforts underway. There was no writing session in the first year because of the awkward timing of the funding. Six additional projects have been invited for the summer of 1974 for a total of 20 texts. COMPUTe has asked the National Science Foundation for a continuation of support in order to build on experience and capitalize on a growing national awareness of the project. The fate of that request is unknown at the time of this writing, although there has been considerable support for it.

One of the difficulties is locating good proposals. Even without a writing session the first year, COMPUTe has received over 80 proposals, but many of them are more plans than reality, and demonstrate a lack of classroom exposure. Many more of them are primarily concerned with teaching programming, and the project has no interest in supporting programming per se. By the time the review process is completed, not many good candidates remain. Thus far, COMPUTe has been able to support all of the outstanding proposals, but has fallen short of the goal of 30.

Because of staff concern about maintaining a high level of quality, COMPUTe has asked permission of the NSF to take a more aggressive posture in locating good authors who are known to be involved in instructional computing, and asking them to submit proposals. This would give the project primary control over the material received for review.

Although the project has no publishing contract, there have been promising developments and discussions in the past six months which lead staff to be confident about locating a publisher who will be willing to take the risk involved in such an open-ended arrangement. COMPUTe has been criticized for not having a contract after three years in operation; but no publisher was willing to get serious until the project was in a position to show some high-quality material in the fall of 1973. Since that time, interest has picked up, and an offer to publish an individual title has led to a discussion of possible arrangements for the entire output.

## THE PRODUCT

The average text being supported by COMPUTe runs between 150-250 pages, double-spaced. In some cases, instructors' material is bound together with the student material, but sold as a color-coded copy. In other cases, it is bound separately but still color-coded. A mixture of narrative about the subject matter, necessary programming technique for dealing with the problem at hand, and copious examples and exercises for the student are sought. Basically, COMPUTe wants a product that resembles a standard textbook presentation.

Programs vary from 8 or 10 lines, which means that all programs for a text could be entered at a terminal by any student or teacher, to a few data analysis programs which contain hundreds of statements and represent a reasonable amount of effort on the part of knowledgeable personnel to transport them elsewhere. The growing expertise of the CONDUIT group will prove to be of increasing value in transporting the materials. All programs to date have been in BASIC or FORTRAN, although COMPUTe does not select proposals on the basis of programming language. In the future the project may do different language versions of a particular text.

## A BONUS

One of the bonus features of the COMPUTe arrangement with the National Science Foundation is that the project is permitted to grant royalties to authors based on the sale of their texts. The royalty is a fixed percentage of the wholesale price, to be shared by the author and COMPUTe. COMPUTe's share is meant to be used for support of additional projects, if the amount ever grows sufficiently large to do so! This was an important principle, which is enjoyed by authors of standard texts when they deal with the commercial sector. Comments from authors have indicated that this is important to them in principle, and that, if COMPUTe were not able to provide them with this incentive, they would be inclined to view their experience and tenure with the COMPUTe project as a launching pad for a "real" book. With the copyright provision, an author is less inclined to withhold the bells and whistles from the COMPUTe version of the text in order to be able to include them in a commercial version later.

Although COMPUTe is not particularly interested in becoming a publisher itself, we have felt all along that it was important to mimic the commercial incentives and make them available to authors of less orthodox material. Right now, we think the project offers a very generous incentive package which, in the short run at least, is probably more attractive to a first-time author than any terms s/he could reach with the commercial sector.

The motivation underlying all this is the desire to entice commercial publishers into this field by showing them that there is in fact a market for computer-dependent instructional materials, and that they should prepare themselves to finance it on the same terms that they currently finance standard texts. A working paper written recently for CONDUIT by John Nevison points out that publishers no longer question *if* they will enter this market, but rather *when* they will enter it.[5] Right now, no one wants to be first. They claim there is insufficient market for the material, and yet there is only one known survey by publishers of the market for such material, and the results of that survey are proprietary.[6] It's pretty hard to prove or disprove the existence of a market for a new product until the product is available to people who might buy it. That's what COMPUTe is trying to do. Once the copy is generated, COMPUTe wants very much to enlist the existing mechanisms and expertise of the publishing industry to market and distribute the printed product. Their financial investment is thus eased, and COMPUTe obtains the desired results: publishers involvement and products in the hands of teachers and students.

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6. Ibid.

# Publication of Computer Curriculum Materials at Hewlett Packard Company

**by Jean H. Danver**

Hewlett Packard Company is not a book publisher, but is an electronics company which specializes in instruments and other electronic devices at the frontier of high technology. The corporate fathers are not interested in producing any product which does not make a technical contribution. How did Hewlett Packard get involved with computer curriculum? To adequately answer that question one should start with how the company found itself in the education computer business and how that developed. That would be interesting but long winded. Let's just say that Hewlett Packard started producing computer curriculum as part of an effort to surround its BASIC language timeshared computer systems with applications, hence, making them more attractive to educators. This was necessary because traditional book publishers had not produced any material, leaving a curriculum void which our customers kept insisting needed filling.

## OBJECTIVES

There are other good objectives for producing computer curriculum. First, pioneering the production of computer curriculum not only helps fill a curriculum void, but also is consistent with Hewlett Packard's objective of making a contribution to a field. Second, the existence of computer curriculum helps build a demand for instructional computing which in turn builds the demand for computers. Also, it may be possible to make some profits producing curriculum since the availability of instructional computers has reached a significant level. Another important factor, not to be overlooked, is that publishing computer curriculum helps to establish the development of such curriculum as a respectable activity. Curriculum development compared to pure research has always been a risky activity for college instructors under tenure pressure. Computer curriculum development is even more risky since little chance of publication exists. By becoming a publisher, HP will alleviate this situation, encouraging more curriculum development and more publishers to enter the marketplace.

## EARLY ACTIVITY

The first attempts at curriculum development at HP were somewhat haphazard. Everyone in marketing in charge of a functional area was doing his/her own thing and nobody, except for myself, had any experience with developing published curriculum. My experience was limited to two years at Dartmouth College with the Secondary School Project and Project COEXIST.

The original activity to which the words Computer Curriculum Project applied was one designed to produce materials for secondary school problem solving. HP planned to solicit proposals and have them reviewed by a committee of educators. The committee would determine the scope of the project, the payments to authors and what proposals would be accepted. In addition, the Curriculum Project inherited a guaranteed to publish contract for four algebra books from the calculator division of HP, and purchased the publishing rights for two physics books by Herb Peckham.

Publishing books is not as simple as it appears on the surface. The proposal review committee idea did not really work. Proposals were seldom adequately written in spite of efforts to establish guidelines. Most of them were esoteric or too specialized because people who submitted proposals had been using computers in curricula too long, they were interested in producing materials which were not what the average person needed. Also proposals received did not cover many areas in which we wanted to produce curriculum, and the review committee never could bring itself to reject anything.

Another problem area peculiar to computer curriculum concerned the status of computer programs. Are they to be supported by the company? If so, that means producing special materials for the support people in the field. Such support greatly increases the cost of publications and hence the price. If the company does not provide support, what happens when a customer discovers a bug in a program?

Once the first books were released, it became clear that selling and delivering them to customers was another problem area. Hewlett Packard's sales and ordering operations are based on selling sophisticated instruments to sophisticated customers. The thought of requiring an average high school teacher to find his local Hewlett Packard sales office to place an order for a couple of books was almost as appalling as requiring a salesperson with responsibility for hundreds of thousands of dollars worth of computer sales to a call on someone who just wants to see a $3.00 book.

Some progress has been made with these problems. For example, HP is selling the books via direct mail, media advertising, shows and public relations. This approach removes any responsibility and bother from the sales force and yet, makes it relatively easy for customers to deal with the company. The sales force uses the books for whatever purposes they see fit.

The support problem could still loom. We have managed to solve all problems so far.

The proposal review committee is falling into disuse. Almost two years of experience has taught us how much material is worth and what materials to inquire. HP is experimenting with joint development efforts, author's workshops and locating good material already written. Future activities will be aimed at specific topics rather than several curricula areas. For example, the curriculum development project might devote a year to university physics and produce a number of books in that area alone.

## CURRENT ACTIVITIES

In early 1973, Hewlett Packard decided that curriculum development was important enough to consolidate all efforts into a single program under the auspices of the original Computer Curriculum Project. Because the project inherited a number of scattered activities, development efforts were postponed in order to turn these various activities into products. However, some of these products launched the project into the college and university area. As a result of our experience with this area, the Computer Curriculum Project will be devoting a larger percentage of its development there in the future. Of course, consolidation unifies HP curriculum activities, gives them a common direction and prevents a considerable amount of wheel inventing. Figure 1 lists 1974 HP curriculum offerings.

Along with consolidation came accountibility. Producing books here and there in order to help sell computers may be a good thing in the short run, but it is hardly consistent with the objectives of filling a curriculum void, making a significant contribution and establishing computer curriculum development as a respectible activity. However, when one produces books here and there just to help sell computers, the documents

Figure 1. 1974 Book Offerings of Hewlett Packard's Computer Curriculum Project

| Name | Subject | Availability |
|---|---|---|
| Attacking Non-Linear Equations | Upper level high school mathematics | Current |
| GRAZE Ecology Simulation | Junior or Senior high biology, ecology or social science | " |
| Functions | Upper level high school mathematics | " |
| Number Sets | Upper level high school mathematics | " |
| Mathematical Systems | Upper level high school mathematics | " |
| Linear Equations and Systems | Upper level high school mathematics | " |
| Project SOLO Computer Topics: | | |
| Matrix Mathematics | High school mathematics | " |
| Trigonometry | High school mathematics | " |
| Mathematics Projects | High school mathematics | " |
| Calculus | Upper level high school mathematics | " |
| Physics | High School Physics | " |
| Geometrical Optics | High school or beginning college physics | " |
| Mechanics | High school or beginning college physics | " |
| Waves | High school or beginning college physics | " |
| Electricity and Magnetism | High school or beginning college physics | " |
| Air Pollution | High school environmental science, college physics, courses which teach computer modeling | " |
| Quantum Mechanics | University or graduate physics | " |
| Electric and Magnetic Fields | Upper level Electricity and Magnetism courses | " |
| Classical Statistical Physics | College physics | " |
| Cases in Computer and Model Assisted Marketing: Planning | Graduate School of Business | " |
| Cases in Computer and Model Assisted Marketing: Data Analysis | Graduate School of Business | Fall 1974 |
| Computer Graphics, Three Dimensional Projects: Theory, Programs and Examples | University and graduate physics and mathematics | Current |
| PILOT Reference Manual | CAI language simulated in BASIC. Teachers of all levels | " |
| COBOL/2000: A Primer | COBOL language simulated in BASIC. High school and vocational programs. | " |

can be justified as a marketing expense and given away if need be. If publishing curriculum materials is to be a serious on-going activity consistent with all of Hewlett Packard's objectives, it must not only support itself, but must become a worthwhile investment for the corporation. Therefore, the Curriculum Project has another objective. That is to make money selling the books. If the project succeeds, users of instructional computers everywhere can look forward to more curricula in the future.

# Creating Instructional Material

### by David H. Ahl

A major gap exists today between the capabilities of computer systems (hardware and software) and the instructional applications material available for use on those systems. Clearly the hardware and systems software are able to perform just about any instructional job but the instructional materials lag behind. Some reasons for this were examined at the EDUCOM Fall 1972 Conference. However, the purpose of this paper is not to examine these reasons but rather to look at some approaches to creating instructional material and see how they're working.

Since 1964, Digital Equipment Corporation has published several handbooks, the best known of which are the *Small Computer Handbook* and *Introduction to Programming.* Thousands of these are sold today to college bookstores and are required reading in scores of courses. Keenly aware of the lack of computer related instructional material and bouyed by the success of the handbooks, the Education Products Group of Digital in 1971 began to seek authors, both within Digital and outside of the company to produce other instructional texts. To date 24 books and booklets have been published by the Education Products Group along with 14 new or revised handbooks published by other groups. Digital has also sought contracts with various local and national projects for the publishing rights to any materials produced. Today Digital has three such contracts, the best known one of which is the NSF-sponsored Huntington II Project.

What are the aspects that must be considered before publishing a text?

What are the relevant facets of production, distribution, and pricing that enter in? These and other questions are discussed under the three broad topics: selection, production, and distribution.

## SELECTION OF MATERIALS

*Widespread Interest.* Because no publisher can afford to publish materials for sales of a few hundred copies, most major publishers have published very little computer instructional material. Interest is frequently specific to a particular school or even one department. A great deal of this is due to attitude, such as the professor at Princeton thinking that a book from Cornell couldn't possibly be as good as one from Princeton and vice-versa. As a manufacturer, Digital cannot overcome this problem, and must seek material which is fundamental enough to have broad acceptance.

*Credibility.* A well known author helps to secure acceptance of material, but the company generally can't afford one. To compensate the material itself must be of excellent quality or Digital loses credibility.

Initially, Digital published most books and booklets without an author name, especially those written internally. Unfortunately, however, such books were immediately branded a manual or a sales tool produced for some crass commercial purpose. Digital now credits the author, whether s/he be in or outside of Digital, and has achieved much better acceptance.

*Transportability.* Ensuring compatibility of materials between various computer systems remains the major problem of selection of material to be published. At the risk of losing some die hard FORTRAN users, Digital has standardized on the BASIC language for instructional applications. However, as the BASIC Standards Committee is finding out and as we have known for years, BASIC exists in a myriad of different versions and forms.

Digital has nine versions of BASIC on its computers; actually they are all upward compatable, but each higher system adds features not found on the smaller ones. Therefore, if a potential author has an EduSystem 50, is it fair to ask her/him to use only the BASIC features found in EduSystem 10? It probably is fair but often the author doesn't agree which leads to the inevitable transportability problem.

Further adding to the problem is the great lack of compatability across manufacturers. A group of representatives of computer vendors has been trying to define a minimum kernal BASIC common to all manufacturers and use that as much as possible for instructional material. Frankly, it isn't a very exciting BASIC and most authors shy away from using it.

## PRODUCTION

Digital has been frankly appalled by the supposedly ready to publish manuscripts we have received from many, in fact, most authors. Editing frequently turns out to be an almost total rewrite or else a 4 or 5 time back-and-forth process between Digital and the author. Mimeographed class notes may be acceptable for one course at one school but are certainly not acceptable for widespread distribution. This is a tough message to communicate to many budding authors. Although Digital is a manufacturer, the company is committed to publishing high quality materials, not something that's just been thrown together.

## DISTRIBUTION

*Money Matters.* The financial issues can be boiled down to a relatively simple equation:

Profits = Revenue – cost

In which,

Revenue = Quantity sold X selling price

Cost = Quantity X printing cost + royalty

Before a book is started, one must make some informed guesses on these items. Crucial is the guess on how many can be sold because this determines the royalty and, to some extent, the selling price.

Some rules of thumb have been developed through experience. Most books published by Digital have sales between 1000 and 25,000 copies. If more copies than 25,000 would sell, the book would be of interest to a commercial publisher; fewer than that and it would have to be priced too high to sell at all. Since keeping accurate track of per copy sales is next to impossible, Digital negotiates fixed one-time royalty payments except in extraordinary cases.

*Books and Tapes.* A typical book or booklet published by Digital generally refers to or utilizes between 10 and 30 computer programs. Frequently, programs are quite long, and it is desirable to distribute the programs separately on paper tape, cards, DECtape, cassette, or MAGtape. But which one? Clearly to distribute programs on all media involves an enormous job of organization and inventory investment. The easiest solution is to simply include program listings in the appendices of the books and let the purchaser type in her/his own. Naturally, users don't want to type in programs and would like them furnished on a medium used by their particular computers. Frankly, Digital doesn't have an answer to this dilemma and now supplies programs on paper tape for about 50% of our books, DECtape for 10-15%, and program listings only for the remainder.

# Chapter 16

## CONDUIT Dissemination and Exchange

### CONDUIT: A Partnership for Instructional Change

**by David R. Kniefel**

Educational institutions have demonstrated a high resistance to change and the adoption of innovative techniques. Paul Mort concluded from data collected in the thirties, forties and fifties that it took 50 years to design and develop a solution to a recognized educational problem and another 50 years for the diffusion of an educational innovation destined for general acceptance.[1] Furthermore, even with millions of federal and state dollars directed at changing educational practice during the late fifties and through the sixties, observable change in educational practice is difficult to demonstrate.

Universities, as distinguished from primary and secondary schools can be characterized as providing the ultimate resistance to educational change. This view is derived inpart from university traditions, which have their roots in the Renaissance, the period during which the European university systems were developed. The university and its professors were viewed as possessing all knowledge, which could be dispensed by the institution and absorbed by the students. The amount of knowledge was finite it was dispensable. However, the current view of knowledge has changed drastically; it is no longer finite. Because facts and information are accumulating at an ever increasing rate, the model of a truly educated person as a storehouse of knowledge is no longer viable. Rather she or he is one who can discover or create knowledge. Thus the focus of instruction is changing from the dispensory mode to one of inquiry. Rather than teaching facts professors are being forced to teach techniques. "How do I find out?" or "How do I solve this problem?", are the central questions underlying the instructional environment in this era of exploding knowledge. Changes in instructional techniques and the adoption of new instructional tools would appear to be a natural result of this changing instructional environment.[2]

The purpose of this paper is not to decry the rigidity of the institution, nor is its function to prescribe the ultimate panacea for university instruction. Rather, it will attempt to demonstrate the method by which CONDUIT and regional computing networks such as the North Carolina Educational Computing Service (NCECS) hope to impact the universities' instructional environment by facilitating faculty adoption of one instructional tool, the computer. Their efforts are directed at materials acquisition and validation, and the training of faculty in their use.

## MATERIALS ACQUISITION

CONDUIT as an experiment in transporting and disseminating computer-based educational materials has recognized the need for ethical curricular products as a prerequisite to instructional change.[3] The requirements of an ethical product are manifold but they can essentially be reduced to two major factors: pedagogical validity; and technical reliability. CONDUIT's efforts to improve and insure technical reliability have resulted in the development of standards and guidelines which regulate the design and production of the curricular product. Programs that blowup, inaccurate input documentation, and so on do little to encourage faculty to adopt the computer as an instructional tool. Specific content of the technical standards and guidelines and their effects are being presented elsewhere but it should be noted that technical reliability of software and its attendant documentation is a primary determinant of faculty adoption of materials. Computer systems reliability is another prime determinant, especially for the computer neophyte. Down time, line drops, and other related problems do very little to alleviate the students' or faculty members' fear of the machine.

Pedagogical validity is perhaps the most important factor leading to faculty adoption of a specific curricular package. CONDUIT has adopted the position that representatives of a specific discipline can best determine the relevance and validity of a given curricular package. Furthermore, unless a successful classroom implementation can be demonstrated the package will not receive the CONDUIT stamp of approval. Discipline committees have, therefore, been established to review available materials and to solicit specific materials from professionals within the discipline. A tentatively approved package is then subjected to the acid test of the classroom. Only then are the resources brought to bear that will bring the product to complete technical and transportable standards.

Pedagogical validity is a term with an almost sanctified quality in tone and tradition. What exactly is pedagogical validity and how does it relate to faculty adoption of materials? The term reduces to two major requirements for materials. They must have easily identified, non-trivial and obtainable educational objectives, and, they must be directed at non-esoteric content requirements of a given discipline. Curricular packages which do not demonstrate the above will not be adopted. Instructional faculty do not have time to devote to trivial, gadget-oriented and non-functional curricular activities.

By providing discipline oriented materials acquisition, and pedagogical validation processes CONDUIT will do much to ease fears of time-conscious, tradition-bound faculty. Furthermore, in future curricular development activities the developer will have a set of technical standards and guidelines which have been demonstrated to facilitate materials transportability across diverse computing environments. The latter point expands the faculty member's market thereby increasing the recognition of her/his efforts by peers in the academic community.

## TRAINING

Regional networks, such as NCECS, which play an integral role in the validation process by carrying out classroom tests and providing technical support, serve their major function by providing faculty training and inservice activities. The first and most obvious training need of faculty related to computer based curricular materials is for the requisite skills required to execute the simplest computer software. That faculty recognize and desire this training is evidenced by the response to a recently announced NCECS workshop on statistical applications. Of 150 applicants, 80 percent applied for the first day's activities which was entitled, "Introduction to Computing".

A second, and perhaps more important need is in the area of instructional technique. As with the materials validation process it has been recognized by CONDUIT and the regional networks that a discipline provides the best framework for workshop activities. Workshop leaders (instructors) have proved to be most effective when they are representatives of the designated discipline. The rationale underlying the above strategy is fairly obvious from the standpoint of communication but a far more important factor is evident to anyone who has observed or participated in these activities. A constant request by participants is "How do you use this package in your course?" or "Can you give us a specific demonstration of how you present this program (or use this data base) in your courses?" Not only are these requests made of the workshop leaders but on an informal basis participants are constantly sharing "trade secrets". Workshops without this aspect, at least in the NCECS experience, have resulted in little or no adoption of materials by participants. In other words, faculty adoption of materials requires not only the acquisition of the technical skills but also the pedagogical skills necessary for the instructional application of the materials.

A third training need was evidenced in the 1973 Summer Institute for Undergraduate Curricular Reform in North Carolina: Quantitative and Computing Techniques in the Undergraduate Curriculum.[4] Eight disciplines ranging from Physics to Music participated in summer institutes from one to three weeks in length. The content of each institute was planned by a discipline committee composed of representative faculty from institutions across the state. In all eight institutes a major component of the training was in a substantive area, specifically analytical techniques. Faculty recognized the need to retool or sharpen skills when faced with the analytic power of the computer and the proposed shift in the instructional environment.

The regional network is at a distinct advantage when compared to the single campus computer center in providing opportunities for training in instructional techniques and analytical skills. The fact that they draw an audience from a large number of colleges and universities allows the requisite training for disciplines and sub-disciplines to be cost effective. Further benefits accrue as faculty adopt computer based materials and revenues increase correspondingly. This is evidenced by NCECS whose dramatic growth has been augmented extensively by curricular applications.

## CONCLUSION

Universities are highly resistant to change as are all educational institutions. However, the changing character of the rapidly exploding knowledge base and the resultant shift in the instructional environment are forces which may bring changes to the undergraduate curricula which many feel are needed.

The application of any innovation to the educational process requires either legislative mandate or a concentrated marketing effort on the part of educators. A study by Orlosky and Smith of major educational change efforts during the past seventy-five years indicates that the latter has the greater chance of success. Specifically, of the successful changes that were accomplished in public education those that were initiated and supported by educators has a success ratio of 2-to-1 over legislative edict.[5] Computer-based educational materials in higher education are, for the most part, being developed and promoted by professional educators. In addition, the discipline orientation of CONDUIT and the associated regional networks in their respective materials acquisition, validation and training activities point to its probable success.

This paper has attempted to identify the salient features of the effort being carried out by CONDUIT (materials acquisition and validation) and the regional computing networks, specifically NCECS (training), which will lead to faculty adoption of computer based educational materials and thereby instructional change.

- Technical reliability of software and documentation. (A pre-requisite for successfully demonstrating this is a reliable computer and communications system.)
- Pedagogical validity of instructional materials substantiated by faculty peer recommendations and demonstrated classroom success.
- Training in the requisite technical skills.
- Training in pedagogical applications of the materials (both formal and informal).
- Substantive training in analytical skills.

Preliminary review of faculty adoption rates and package utilization statistics within the NCECS network indicate the success of the approach outlined above. Announcements of workshops are bringing increased response from new faculty. The ultimate measure of the success of the CONDUIT and regional network partnership will be resultant changes in instructional procedures. While the initial effects may seem relatively small and difficult to observe, the aggregate demand for change and increasing evidence of faculty interest should produce substantial results.

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# Technical Problems in Moving Courseware

**by Trinka Dunnagan**

The CONDUIT project has been studying transferability of those computer-based materials considered suitable for undergraduate instruction. In the first two years, over eighty programs have been exchanged and monitored among the five regional network centers. Originally these programs were exchanged according to the historic method: a source deck was duplicated, either onto tape according to the favorite local format or onto uninterpreted punched cards; a packet was made up of related printed materials; and the resultant pieces were mailed together (or separately) to an unlucky recipient. With this method, the burden of transport would fall upon the receiving site while the distributor enjoyed an attitude of out of sight, out of mind. Within CONDUIT, four centers out of five would approximate each others' efforts to implement the program while working under the same handicaps. Observing such random but representative transfers, CONDUIT central staff concluded that the underlying process could be improved. Many apparent, often trivial but harassing problems could be alleviated, and overall transport costs could be reduced. To aid in the search for ways of improving the transfer process, staff characterized the four major process functions as: selection; packaging; delivery; and implementation. Each function poses questions of strategy, priorities and cost-effectiveness which are now under consideration.

## SELECTION OF CURRICULUM MATERIALS

Special curriculum committees advise CONDUIT on the selection of computer-based materials for transport. Questions to be asked in selecting a program include:

- Is the program theoretically and operationally correct?
- Does the use of the computer represent a valid educational approach?
- Has the program been tested, debugged and used in the classroom?
- Is it possible and desirable to transport this program?
- Are both the technical and educational documentation sufficient for usage at a new site?

## PACKAGING THE PRODUCT

Curriculum coordinators, programmers and faculty contribute to the preparation of programs for exchange. A definition of packaging has been evolving as CONDUIT builds up transport experience. The initial questions concerning packaging are:

- How much does packaging affect program exchange?
- What minimal standards are necessary for technical transport?
- What minimal standards are required for transferring pedagogical techniques to a new class situation?
- What are the trade-off benefits of upgrading packaging at the originator's site rather than the receiver's site?
- How can effective incentives and sufficient information be provided so that authors will create transportable, computer-based instructional materials?

## DELIVERY

The present CONDUIT delivery system is based upon a soft network of curriculum coordinators and their staffs, who exchange programs and promote new materials within their networks. The issues in facilitating this delivery system include:

- How much communication between distributors and recipients is needed?
- How can duplication of work at multiple centers be minimized?
- What factors will ease the total transport process?
- What evidence, explanation and encouragement is necessary to promote faculty usage of new materials?

## IMPLEMENTATION

The curriculum coordinators and their programmers, over the last two years, have provided CONDUIT with information on implementation which involves debugging, testing and maintaining new materials for users at their regional networks. In the course of implementation and subsequent adoption by interested faculty, a great deal of case history data has been collected. These data raise technical transport problem questions such as:

- What procedures and materials are needed to facilitate implementation at a receiver's site?
- Do standard problems reoccur for each recipient?
- What services should the distributing site provide?
- Will analyzers or standard translators improve transportability? If so, when should they be used?
- Can procedures be established for program validation at a receiver's site?

None of these questions posed are irrelevant to CONDUIT concerns. Transport problems encountered are directly related to the foregoing issues. One should realize, too, that the cost and confusion caused by a single problem is not always predicted by its importance or complexity. Trivial bugs are often the most frustrating and time-consuming to rectify. Lack of correct or adequate documentation will make mysterious, otherwise simple code, and solutions to such problems lie not in one-time measures, but in a thoughtful revamping of the overall process.

Representative problems reported at CONDUIT receiver sites illustrate how appropriate a re-evaluation of the historic transport process is. If the computer application was trivial, although the package looked interesting, faculty felt there was no justification for computer usage in the classroom. Because the package required special facilities which were not available to remote school users like a card reader or because the program's application was inappropriate for class size, it was not used. Often sample input and output looked good, but since not all options had been tested, the program contained many small errors which had not been previously encountered. If the package, although apparently useful and well-documented, was theoretically unsound, algorithms performed incorrectly and calculations did not give the claimed results. Often program documentation did not match the program. Documented variables were reversed, overlooked or non-existent. Card decks were accompanied by out-of-date listings, and tapes contained unexplained "garbage" files which had been ignored. Sample input and output was either absent or had been generated from the working load module which did not match the program being exchanged.

Variance in local charging algorithms made inexpensive operations exorbitantly expensive in a new computing environment. System dependent features caused strange results on new machines. Calls to external routines, use of free format I/O, assumed end of file behavior, comparisons of small numbers, expected ordering of operations, and so on generated interesting but not useful disparaties on different machines. Tape writing, especially blocking and use of a "standard" character code such as BCD, caused wide-spread difficulty among the CONDUIT centers. Some reblocking had to be done character by character in order for files to be useful. BCD, although almost standard, varied by a few, sometimes unreadable, characters among the systems.

Staff concluded from this experimental phase of CONDUIT that guidelines for program selection documentation and technical transport should be drafted and tried. With cooperation among network centers, standards are being implemented in 1974 and the results measured. CONDUIT's objective is to regularize the transport process, thereby encouraging credibility and rewards for development of good, computer-based instructional materials.

# Computer Influence Peddling

**by Ted Sjoerdsma**

In 1974, there is little debate about the influence computers can have upon instruction. There may still be much quibbling about the best method or the better cost-effective procedure, etc., but everyone by now has seen (or heard of) an impressively effective instructional use of the computer. On the other hand, no one believes that the computer is now being used to capacity as an instructional aide in all classrooms. Therefore, "computer influence" needs to be peddled.

Since 1968 in an NSF funded effort to determine where the curriculum could be enhanced by computer use in the classroom, and more recently as CONDUIT coordinator at the University of Iowa node, as well as manager of academic services at the University Computer Center, I have had much opportunity to encounter the elements which stand in the way of transportability or the easy and free movement of computer-based curriculum materials from one classroom to another. Some of the problems encountered and solutions used with varying degrees of success may be useful to others.

## OBSTACLES IN TRANSPORTING INSTRUCTIONAL MATERIALS

*Faculty Attitude.* There is still much fear, awe and negativism among the faculty members not yet involved in the instructional use of computers. Many look at the computer expert as they would view a dentist: necessary, but to be avoided because any contact is invariably painful. Although not all newly contacted faculty fit this description, it is necessary for the influence peddler to demonstrate support and helpfulness. If one is to convince a faculty member that a computer package merits consideration, he or she must first win the instructor's confidence. Academic programmers should feel the obligation to write and document programs so that they are highly intelligible to the layman. All contact with faculty should attempt to remove rather than enhance the mystique of computer experts.

This negative attitude tends to prevent the uninitiated from using the services that could help them overcome the problem. Sixty-nine percent of the participants in the CONDUIT national workshops were faculty who had used computers in the classroom in the previous year. Truly, "the rich get richer,..."

*Lack of Reward.* Even though there are small clouds on the horizon that portend change, the general academic milieu is still overwhelmingly "publish or perish." Certainly it is not "compute or perish," nor should the pendulum ever swing that far. One small cloud of promise is the fact that some department heads at the University of Iowa, when making recommendations for promotion, have been requesting information from the staff of the University Computer Center concerning the quality and character of the faculty members' computing ability. At least two members of the university faculty have already won promotions in which their computing ability and computer-based course development played an important role. It is important to promote at high administrative levels, an attitude favorable toward rewarding instructional improvement.

The above comments apply primarily to the university type campus. At the smaller colleges, teaching ability, innovation in the classroom and development of computer-based instructional materials, already seem to be highly regarded. Fifty percent of the attendees at CONDUIT national workshops were from schools with 6 or fewer faculty members in their department. Eighty-nine percent of these ranked themselves as teachers, as opposed to researchers or curriculum developers.

Rewards are also lacking for the development of computer based instructional packages. A textbook still has more chance of monetary reward than a set of excellent computer programs. One of CONDUIT's roles could well be to enhance the computer product and promote its marketability.

*Extra Time and Effort Required.* The faculty member who approaches the possible classroom use of computing expects to spend more time and effort to be able to accomplish his goal. (See Figure 1) Experience shows however that the actuality is even worse than anticipated. If a computer language is introduced, there are more questions and topics. If computer tutorials are to be developed, extreme effort goes into initial development

**Figure 1. Data from CONDUIT national workshops**

Participants were asked to evaluate materials and then were asked to rank the importance of the question on a scale of one to four: 1-extremely important; 2-important; 3-low importance; 4-completely irrelevant. Of 21 questions asked, the top 11 in order of times "extremely important" was cited, are listed below.

| % responding "extremely important" | Question Asked | Total % responding "extremely important" and "important" |
|---|---|---|
| 60% | I have enough support to use these materials (training, guidebooks, etc.). | 90% |
| 53% | I can solve problems of scheduling students onto computer terminals. | 88% |
| 51% | I have enough time to integrate and use these materials. | 90% |
| 43% | These materials are on an appropriate level of difficulty. | 83% |
| 42% | I can solve management problems (credit hours, student space, etc.). | 79% |
| 34% | These materials broaden course related student experiences. | 91% |
| 32% | These materials include adequate student guidance. | 86% |
| 31% | These materials allow my students to learn more independently. | 76% |
| 30% | These materials can be readily tailored into my course. | 80% |
| 29% | These materials will teach my students new and important skills. | 79% |
| 29% | These materials include adequate instructor guidance. | 79% |

and when the finished product is obtained someone is always asking for a new evaluation. CONDUIT classroom test participants agree with this contention. They reported spending considerably more time on their course because of the inclusion of computer materials. It is true that the computer can remove much of the tedium in teaching but this simply allows the teacher to apply her/himself to more pertinent tasks.

One can only agree with a teacher's anticipated extra time and effort, so how does the computer influence peddler handle such an objection? The best approach is to stress that the key to all computer-based instructional materials is student benefits. Computerized curriculum materials are not developed for teacher benefits but rather to allow students deeper insights, more realistic problem solving capabilities and better simulated experiences, all geared to their individual needs in learning. All this is usually accomplished through an exciting and effective learning experience which includes active participation rather than a passive absorption.

*Unfamiliarity.* The problem of unfamiliarity occurs at many different levels. It runs from unfamiliarity with computer jargon (this is true in every discipline), to the newness of material or equipment, to the factors which make each computer center and each instructor unique. For example, a program recently transported between two CONDUIT node networks was initially unused by already computer-conditioned faculty at the new node. Although documentation was probably better than that usually accompanying a new package, it was used only after the documentation was reformatted into the form familiar to the faculty. As another example, when I recently attempted to try a program at a remote CONDUIT node, I received a message on my terminal which caused me to abort the attempt. I later learned that the message was a normal function familiar to that network's users, and that I could have continued my experiment. Just a small amount of unfamiliarity stopped the activity!

How can one solve the problem of unfamiliarity? Much can be done. CONDUIT is helping with guidelines for technical transport, guidelines for documentation, and even guidelines for writing transportable programs. These will help provide a familiar format. Computer materials must be described in the language of the instructor's discipline not in computer terms. Workshops, with consistent follow-up assistance, can overcome a large part of the problem of unfamiliarity by allowing direct use of the product as well as equipment. (See Figure 1)

*Lack of Equipment.* This is a different type of problem which is directly tied in with lack of funds in many cases. However, inexpensive terminals connected to larger computers can often supply an amazing amount of computer power to a classroom. (For high relevance ratings faculty, see Figure 1.) Necessity is still the mother of invention and there are many examples of ingenious ways to use limited resources to provide necessary computer power. Anyone with such a lack of equipment should be encouraged and supported in an effort to obtain equipment and funds through grant applications to a variety of funding agencies.

*Lack of Funds.* This is usually the other horn of the lack of equipment dilemma. Sometimes lack of funds is due to a lack of priority within the administration which requires whatever tactics work in a particular institution. The best approach can range from gently and tactfully reeducating top administrators to openly demanding a shift of emphasis. It is wise to bring in reinforcements so that the request for funds for computing come from several interested departments as well as the computing staff.

If there is no source of funds available locally (or if the above approach fails), it is time to get into the proposal writing mode. Most colleges have a list of funding agencies, including NSF, NIE, NIH, Exxon, Ford, etc., who are always approachable with novel ideas and they sometimes support ideas that are not so novel at institutions with special characteristics. The computer influence peddler can be most helpful in keeping abreast of funding opportunities and assisting in the formation of a sound proposal.

*Lack of Educational Documentation.* Even if all of the above mentioned problems have been already solved, one still looms large as an obstacle to the easy transportation of a good instructional computer package. If the package does not contain a careful description of its purpose, how it serves that purpose and how it is integrated into the actual instruction in the classroom (educational documentation) it is doomed to gather dust. The best educational documentation can usually be provided by the original developer. However, it is possible to obtain such information from subsequent users.

*Differences in the Individual.* Probably the largest stumbling block in a smooth transition of a computer-based instructional package from successful use in an originator's classroom to another classroom is the fact that each teacher is an individual. Each person is unique. Each teacher uses different techniques and applies a given fact in a different way. Each approaches a topic from a different direction.

There is a simple direct solution to this problem, but it is not recommended. The solution is genetic engineering or cloning by making all teachers exact copies of one another. It is preferable, however, to continue to combat all the obstacles that arise and even forego transportability of computer instructional material, rather than give up the endless variety of thought and application in teaching that now occurs.

## SUMMARY

There are many obstacles in the road to transportation of computer-based instructional materials from classroom to classroom. Some of these obstacles are easily removed by the computer influence peddler, some will never be removed since they are rooted in individual differences.

CONDUIT has already attacked some of the obstacles of unfamiliar material and lack of documentation by means of its published guidelines. It should also help to give visibility and stature to computer materials so that the reward for development and use of instructional materials may increase. The future is certainly much brighter than four years ago.

## REFERENCE

1. See Proceedings of Conferences on Computers in the Undergraduate Curricula; 1970, 1971, 1972, 1973. These were provided free by N.S.F. to the library of every institution of higher education in the United States. Copies are available at $10 each from the University of Iowa Computer Center.

# Significant but Reducible: The Cost of Transport

**by James W. Johnson**

The CONDUIT experiment has provided insight into cost of transfer of computer-based instructional materials. The most important finding in cost of technical transfer is non-zero and significant and offers a partial explanation for lack of wide-scale transfer. Labor cost, not computer time, of making packages operational at the five CONDUIT centers in seven disciplinary areas is illustrated in the chart below.

These transport costs have been compiled by coordinators at the CONDUIT networks and include time involved in tasks of reading documentation, writing user instructions, instructing programmers, contacting source site, etc., as well as debugging.

## INTERESTING RELATIONSHIPS

Before making general observations about the cost figures illustrated in the chart, discussion of the figures themselves is in order. Although the order of magnitude of cost for a given set of materials is the same between networks, the overall variety is striking. The reasons for the variety are numerous but a few are of interest because they suggest ways of reducing cost.

Labor cost charges varied from $2.00 an hour for student programmers to $8.50 an hour for curriculum coordinators. In many cases the higher priced labor was necessary because transport problems are not well

Figure 1. Time in $ in transport tasks

| Discipline | Dartmouth | Iowa | NCECS | Oregon State | Texas | Average |
|---|---|---|---|---|---|---|
| Chemistry (2)<br>(37 programs) | $2100 | $1050 | $2625 | $1750 | $1200 (1) | $1750 |
| Biology (4)<br>(20 programs) | -0- | 925 (1) | 600 | 800 | 300 | 650 |
| Physics<br>(Integrated package of small programs) | -0- (1) | 190 | 90 | 520 | -0- | 140 |
| Business<br>(20 programs) | 1575 | 820 | 680 | 1850 (1) | 275 | 1040 |
| Social Science<br>(9 data bases) | 320 (2) | 1640 (3) | 2380 (1) | 2680 | 1010 | 1610 |
| Economics<br>(4 programs, 1 data base) | 460 | 1040 | 1792 | 2400 | 230 | 1180 |
| Mathematics<br>(Integrated, 5 subroutines) | 190 | 290 (1) | 325 | 375 | 20 | 240 |

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(1) Workshop and source site

(2) Not complete package

(3) NCECS workshop site, but Iowa source site

(4) Part of special distribution test, assigned to Texas and NCECS.

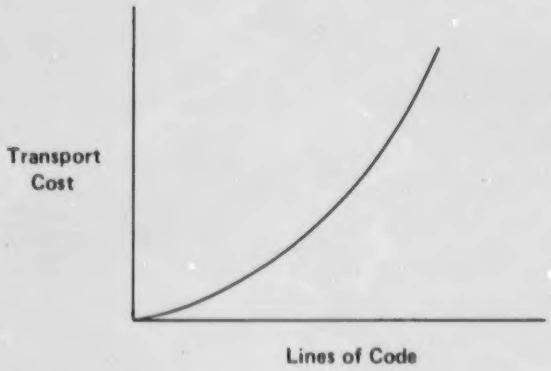
defined, the process is not systematized, and the solution requires knowledge of the substantive content of the program.

As expected, the CONDUIT test packages were used in varying degrees at the network schools. The more heavily used a package, the greater the possibility of bugs appearing and the need for modification. For example the economics materials were not extensively used in the Texas or Dartmouth networks and therefore substantive errors in content were not detected and corrected.

The nature of the package transferred also has an impact on cost. The physics and mathematics materials were integrated packages in that they relied heavily on textual presentation and involved the student in programming tasks. The programs that were moved, at the discretion of the instructor, were straightforward algorithms that are easily replicated. Dartmouth converted the five subroutines contained in the Linear Algebra mathematics package for FORTRAN to BASIC for a reported cost of less than $200.

A most interesting factor responsible for cost variance was the size of the program. While transport costs averaged 35 cents per line of source code, small programs averaged much less while large programs averaged more. This relationship between lines of source code and conversion cost is demonstrated graphically in Figure 2.

Figure 2.



This observation should not be surprising. As programs increase in size their complexity increases exponentially causing great difficulty in correction and maintenance operations.

The importance of these relationships is that they immediately suggest ways of reducing transport costs. If the transport process is well-defined and systematized we can substitute low-cost labor for scarce, high-cost labor. While not all packages contain small, easily understood algorithms, large programs can be divided into less complex modules that are self-documenting. Review and testing before transport can reduce total system costs by eliminating duplication of effort at several sites. CONDUIT is utilizing these findings in preparation of standards, guides and procedures for easing the transport process.

## SIGNIFICANCE OF THE COSTS

Despite the variation in costs from network to network, CONDUIT test data clearly indicate that transport costs are significant. An average cost of over $1,000 to make four programs and one data base in economics operational when expected use is problematical in an expenditure that computer centers and academic departments can ill afford. To some, these costs may be grossly over-estimated because they do not represent actual out-of-pocket costs and because they include tasks such as providing user instructions in the process of making materials operational. However, hour costs are realistic in that they are a charge for use of a resource that could be used on other tasks even if an additional expenditure is not made. Calculating the full cost of transport as the effort to making a package operational in the classroom is justified with the realization that a compiled program with no user instructions can never be used.

The transport cost estimate of 35 cents a line of source code represents a significant barrier to transfer of computer-based curriculum materials. Yet this cost is slight relative to expenditure for new or re-development. Thus the current state of affairs suggests a paucity of new instructional packages at academic computer centers because of cost considerations. Fortunately this problem can be resolved by reducing transport costs, a project that CONDUIT is now addressing. Preliminary findings are that cost of transfer can be reduced by a large factor.

# Chapter 17

## CONDUIT Guides and Models for Solution of Transport Problems

### Overview of Alternatives for Transport

**by Thomas E. Kurtz**

As a result of the experience gained in the experimental phase of CONDUIT, several of the problems associated with the dissemination of computer oriented curriculum material have been identified. Assuming that transportable and pedagogically sound packages exist, suppost that institution A has such a package, and that institution B wants to use it. What are the possibilities for transport? In what ways can B use A's package?

First, the method of transport depends on the *form* of the package. One can identify three such forms.

- Printed (book or listing)
- Machine readable (cards or tape)
- In a machine

Next, the method of transport depends on the *mode* of supplying computer resource to institutions A and B. One can again identify three such forms.

- *Local isolated machine*
- *Star network*
  At the hub
  At a point
- *General network*
  Local machine or terminal
  At the hub of a star
  At the point of a star

There are 27 combinations when there are available three forms for the package, three modes of computing for A, and three modes for computing for B. Each of these 27 combinations suggest the use of one or two methods of transport. It is not necessary to construct the 27 entry table, in order to isolate several of the preferable alternatives for institution B.

- Buy a text, and type in the program.
- Convince the hub of B's star network to type in the program.
- Transport over the network from A to B, use on B's computer.
- Transport over network from A to B's *hub*, all points of the star then use on B's computer.
- Keep the program at A, where it can be used by B over the general network.

The above list is not intended to be exhaustive. Until technical and operational difficulties and costs for computer networks are greatly reduced, more simple and direct methods of program exchange are preferable. For instance, the form, mode, and method currently used in CONDUIT is to mail magnetic tapes when the form of the original program is magnetic tape, the mode of operation at A is a star network, and the mode of operation at B is a star network. Thus, CONDUIT currently transports computer related curricular materials by exchanging tapes between the hubs of star networks.

# CONDUIT Cooperation with Project C-BE

**by George H. Culp**

Last year instructional computing application accounted for over 560,000 jobs at the University of Texas Computation Center. A significant portion of these were related to Project Computer-Based Education or C-BE. Project C-BE, directed by Dr. J. J. Lagowski and Dr. J. J. Allan, was funded in 1971 by the NSF and the University at the level of 1-1/4 million dollars. Ultimately the project over a four period will involve over 44 separate projects, 75 professors and upwards of 4000 students in which computer-based techniques are used to supplement instruction.

Currently 25 projects are in development or evaluation. Approximately 1200 students are consuming around 2000 hours per week on interactive terminals in disciplines including chemistry, physics, psychology, engineering, statistics, biometrics, linguistics and home economics.

Although development of computer-based curriculum is an integral part of the project, this is not its primary objective. Rather, the four basic goals of the project are to

- Identify common concepts of computer-based education among the disciplines;
- Develop evaluation schema;
- Develop transferability criteria; and
- Develop a model for implementing computer-based instruction techniques.

It is in the area of transferability in particular, that Project C-BE and

CONDUIT goals overlap. In this regard, a close working relationship between the two projects has developed. This cooperation includes an interchange of documentation of results that give insights to effective transportation and dissemination such as the CONDUIT documentation and transportatiliby guidelines. In addition, CONDUIT and C-BE are working jointly in conducting transferability tests for certain C-BE packages as they are developed, and workshops will be held jointly for the transportation and dissemination of materials. For example, a C-BE/CONDUIT/Texas sponsored workshop in macroeconomics has been held where computer-based materials were disseminated to more than a dozen institutions of higher learning.

Finally, a CONDUIT/Texas member serves as a representative on the Project C-BE transferability committee. The guidelines and standards developed by CONDUIT will be an integral consideration as Project C-BE materials are developed for transportation. Close harmony between the two projects should lead to materials that will be more readily transportable, and the excellent working relationship between the two projects will be of mutual benefit as the problems involved in disseminating computer-based materials are jointly resolved.

# The Untapped Market for CRCM

by Clifford F. Gray

The use of computer related curriculum materials (CRCM) in the college classroom has come a long way from the experimental attempts of the late fifties. The growth of CRCM in undergraduate education can be observed historically by using W. W. Rostow's five stages of economic growth: traditional society; preconditions for take-off; the take-off; drive to maturity; and high mass consumption.[1]

In the late fifties the basic computer technology was available to students in the larger universities. Some attempts at using the computer to augment standard teaching approaches indicated great promise, notably the use of business games. The stage was set for a change from traditional teaching methods to the use of computers as an alternative teaching mode. In the early sixties the preconditions for take-off began to appear on the horizon. Limited experiments in the development and use of new computer teaching methods further confirmed the potential for computers to augment standard classroom procedures through computer assisted and managed instruction, games, simulations, and algorithms. By the late sixties and very early seventies the take-off stage was evident. Expansion of technology, techniques, and skills was rapid yielding mass batch processing, interactive modes, graphics, special and improved languages, improved software. New developments and approaches were spread in the profession and in the journals. In 1974 computing for undergraduate instruction is approaching the drive to maturity. Growth is sustained and the number of applications increasing. The state of the art is being extended on every front. Faculty in many disciplines have the ability to identify the consumer, design and produce a high quality product, and organizations are capable of coordinating the production and distribution of our product.

Tomorrow colleges will be entering the age of high mass consumption. In this stage a large number of consumers are aware and desire to consume the product which must appeal to a large audience, be somewhat standardized, and be produced at a low cost compared to substitutes. Computer curriculum materials are rapidly approaching this stage. However the audience to which the CRCM will be directed in this stage may have a different profile than the majority of the earlier users.

## THE UNTAPPED MARKET

The untapped market for CRCM is in undergraduate programs in many of the basic required courses where the potential users are college faculty and students who typically have little or no experience with computers. In many universities with large computer centers and high student usage, more than 50 percent of the students have still had *no* computer experience in 1974. The potential market represents institutions of higher learning which have a wide range of extensive computer support facilities. Although over 1200 colleges already provide the computer support facilities for their faculty and students, relatively few schools and students are enjoying the benefit of CRCM. The major cause for the lack of use is the difficulty of transporting materials.

In the 1960's the development of CRCM has been so voluminous that federal agencies have provided millions of dollars to support over twenty clearing houses to facilitate early exchange and dissemination of computer related materials. It would be conservative to say that clearing houses have collected over 5000 computer related packages for undergraduate instruction. Typically although these clearing houses are flooded with requests for CRCM, follow-up indicates that the track record for successful transfers has been dismal. What accounts for such an appalling record? Experience has shown that, frequently, CRCM packages are not used because the computer materials are not transportable.

Transportability involves all the efforts necessary for the successful exchange and implementation of the computer related materials into another curriculum. Physical exchange of a computer package seldom means that it is available for use without technical or software modifications. The seriousness of the transportation problem is difficult to exaggerate. The Business Curriculum Committee of CONDUIT has reviewed several hundred computer packages to see if the materials could be placed in the CONDUIT library. It is estimated that over 95 percent of the materials reviewed could not make it past the first stage of evaluation. The primary reason for their rejection was not technical, but rather an almost complete lack of documentation for the users.

A notable exception to this record were those publishing companies which distribute computer related materials. Why do they have such a high success ratio? A cursory examination of their successful products tells us the key ingredients for successful transplants of CRCM have been known for years; unfortunately, we in the academic have not had to respond to the compelling force of the direct profit motive.

## LAUNCHING A NEW PRODUCT LINE: THE CONSUMERS

The key ingredients for marketing CRCM are: identifying the customer and the specific needs of the customer; the production of a high quality product at a reasonable cost; and an organization capable of coordinating the production and distribution of the product line.

*Identifying the customer.* In addition to the objective of reaching the vast, untapped market of undergraduate students in those basic courses where CRCM would be useful, a surrogate objective is to provide an equal opportunity to all faculty and students to use the CRCM developed. This objective is specifically designed to reach those institutions which could be linked to a large computer center. The next step is to consider the needs of the users.

*Identifying the needs of users.* The ultimate users of CRCM are faculty and students with a wide range of computer sophistication. At the high end of the continuum are a few faculty and students who have considerable knowledge of computer technology and languages. At the other end of the continuum, where the bulk of the users are found, are those users and potential users who have little or no sophistication in the use of computers. If one defines the market segment as basic courses and small institutions which are linked to a larger computer center, it is imperative that the needs of the users at the lower end of the continuum be met. Faculty and student CRCM users have different needs. Clearly, if the individual faculty member does not wish to use the CRCM, the student will never enjoy their benefits.

*Faculty needs.* First and most fundamental, the potential faculty user must feel the introduction of CRCM will improve the teaching environment: improve teaching; heighten student interest in further study; evoke a positive attitude of acceptance; improve student learning and performance; or bring more realistic problems to the classroom. Evaluating information on CRCM can be obtained from colleagues, but, for most faculty a central organization that would review, test, evaluate and certify that the materials have been used successfully by others would be most useful.

Computer materials must also be pedagogically sound and accurate. The content of the materials should have a theoretical base that is easily found in the literature, and computer programs should be tested and checked for accuracy. To complete a review of CRCM at least two source people should be easily accessible to judge questions of pedagogy and the technical accuracy of the programs.

The time and cost to startup and to get the materials implemented into the classroom must be small. For example, some of the successful computer augmented materials require as little as 3-4 hours of faculty time for installation. If startup requires days or even weeks, the faculty member should receive released time to prepare. Regional workshops, which have been especially successful in helping with startup problems, could be handled best by a central organization which could draw on experienced instructors for the workshop. Although this method is expensive, it seems to be the most effective.

If the computer materials have educational validity, they should be *technically* transportable; error free and operational on other computers at other locations in minimum setup time. Two successful computer related materials in business may be run on IBM 1130, IBM 360, CDC 3300, and CDC 6500 computers. These two packages when tested were nearly error free. The actual setup time for each set of materials was less than four hours for a computer center staff specialist. If one's objective is to encourage use of CRCM, the faculty member should be freed from the task of getting the programs to run on the new system. An agency to test the program and certify that it is technically transportable would do much to alleviate the transport problem.

Besides being technically transportable, the CRCM must be supported with adequate software so the instructor can implement the materials with as few problems and as little effort as possible. Because there has been little incentive for developers to provide completed software to accompany programs, approximately 95 percent of those packages examined failed in this dimension. Academia has done little to reward those who pursue the development of CRCM although the economic incentive and professional rewards of writing an innovative text have been enough for a few to try to meet the needs of the faculty member by offering completed software packages to be included in the instructor's manual. A synthesis of the unpublished guidelines suggested by publishers to developers indicates the kinds of software needs that must be satisfied:

- Teaching objectives for each module should be clearly stated Gronlund's *Behavioral Objectives*[2] is suggested as a guide.
- An example that can be worked manually along with sample computer output
- Sample computer results under different conditions
- References which describe the theory and method used in the computer programs

- A detailed description of the educational philosophy and advantages of the computer approach
- Actual classroom procedures and format
- Extra exercises for student review and testing
- A statement of expected setup time, estimated computer costs, and manpower requirements
- Problems encountered by students and amount of time spent in preparation outside the classroom.

Instructors attempting to use new, innovative approaches to education should be rewarded for their efforts by their departments or schools. When promotion, tenure, and salary reviews fail to reward this effort, the faculty member soon looks for greener pastures. Some groups and organizations must carry this message to the administrators who are making these decisions on reward.

Finally the instructor should have some assurance that if time is spent setting up class materials for computer exercises, the documentation and programs will not be changed – say, three months later. Although this may seem a trivial impediment to the generation of CRCM it has caused a few faculty authors to "give up."

*Student needs.* Student needs are similar to faculty needs. In general, students in basic courses will have had little or no experience with a computer. Therefore, if the subject will allow it, the amount of input should be minimal.

Sometimes students report that it is difficult to discern why they were asked to perform a given exercise. Every exercise should have an obvious point and be sharply focused for the student.

If appropriate, student manuals with instructions, sample output, input formats, and exercises should be provided to accompany a basic CRCM.

Problems should progress from exercises to more difficult evaluative problems where appropriate.

Finally, preparation time for the use of CRCM should not be significantly greater than for a traditional course.

## PRODUCTION OF A HIGH QUALITY PRODUCT: DEVELOPERS

The production of high quality CRCM at a reasonable cost depends almost wholly on the willingness of faculty to design and develop CRCM. What must be done to encourage faculty to devote time and effort to this activity?

Developers must have some guidance in terms of the needs of their academic discipline and colleagues. Although several sources are helpful, such as publishers, research studies, and reports from professional organizations in particular disciplines, direction at the national level could assist developers.

Developers also need a set of technical and software guidelines. Some publishers provide software guidelines which follow those usually given for textbooks, but there are no technical guidelines except the American National Standards for FORTRAN. Fortunately several publications of guidelines for developers will be published soon. However a central organization accepted by the computer industry would go a long way in solving a very difficult problem.

Developers of small independent computer curriculum materials need an organization at the national level to publish and distribute their materials. Since commercial textbook publishers are reluctant to enter this market, an organization similar to the Harvard Case Clearing House could be developed to meet this need. If the materials received were reviewed, tested, and certified, the materials could be considered a "publication" for purposes of tenure review.

Perhaps the biggest need the faculty developer has today is that of recognition by professional colleagues and administrators who determine salary, promotion, and tenure. Faculty who have spent as many as five years developing CRCM which have gained them national recognition have failed to get tenure or economic benefit from their institutions because their work is not research. If this state continues or gets worse, there is little hope that the needs of the untapped market will be met in the near future. The problem seems to be a national one.

How can the needs of faculty developers be met? There are no easy solutions to this problem, but three suggestions are given as a partial solution.

*A national organization could be formed to review, certify, distribute, and in some cases publish CRCM.* This organization would be performing a screening function similar to those performed by professional journals.

*Professional organizations in the various disciplines should recognize CRCM as a part of regular curriculum development efforts.* The impetus for this movement could come from the faculty members who pay the dues. Actually several professional organizations are in the process of doing this – in business an accounting organization has established a separate area to cover CRCM. They have also set aside some space in their journal to cover developments and research in CRCM. The American Institute of Decision Scientists is taking steps to make CRCM a part of their educational development thrust. This movement, which appears to be gaining momentum, should give the development of innovative computer materials greater stature within the faculty member's profession.

*All school accrediting organizations should include the use of CRCM in requirements that the school be continuously devoting some of its resources to innovative instruction.* If the use of CRCM is a part of the written objectives of the school which accrediting organizations are checking, there should be reward for it in the form of promotion, salary, and tenure.

Because commercial publications yield economic reward and in some schools are acceptable for meeting promotion, salary, and tenure requirements, developers need commercial publishing houses which are willing to publish, package and distribute the software that accompany CRCM.

Developers and publishers also need an organization to distribute the programs. A central organization for all disciplines could meet this need.

Finally, developers and disciplines need financial support from funding agencies committed to improving the educational process.

## PRODUCTION AND DISTRIBUTION OF THE PRODUCT

Many of the needs of users and developers can be met by a national organization set up to facilitate the production, movement, distribution, and use of CRCM. The CONDUIT organization is ideally suited to perform this valuable and imperative function. CONDUIT is committed to the belief that CRCM can improve the educational process and that the exchange of CRCM is a good thing. Furthermore, CONDUIT serves almost 100 institutions with over 275,000 students, and is a national attack on the problems of production, movement, dissemination, and use.

CONDUIT serves users in several ways. CONDUIT Central serves as a repository for CRCM in several disciplines. Each faculty member at each participating institution is provided with a catalog of the materials available in his or her discipline which includes only those materials which have been reviewed by professionals in the discipline and judged transportable in a technical and software sense.

The central organization coordinates the gathering of information from curriculum committees, users, and regional centers to screen each set of materials that will be included in the CONDUIT library. The complete coordination process involves review, testing, evaluation, and certification.

Regional centers provide staff specialists to answer technical questions for faculty users, and sponsor workshops for users in the region. Any interested school or institution can be linked to a regional center and enjoy the benefits of the national organization.

To free the faculty user from the hassle of getting programs on line, the regional center is responsible for putting packages on line that have been recommended by the curriculum committee of the respective discipline. Technical transport problems are no longer an issue for the individual faculty member.

A national organization such as CONDUIT can also meet many of the needs of developers. As the national organization gains experience and maturity it can identify those areas in disciplines where CRCM could improve the educational process or fill a void, for example, the use of graphics to teach economic forecasting to business students. Since developers have little sophistication in understanding the total transport problems, the CONDUIT organization has already written technical and software guidelines for developers. Following the guidelines would yield a 25 percent savings in development time and would also improve the chances of the materials eventually being used by others and thus certified.

Because CONDUIT is a national organization with regional networks, it provides a very quick and low-cost method for disseminating CRCM. For example, one regional center is responsible for initial setup of the materials so they can be used by all the other regional centers in the national network. This initial setup makes the program(s) available to 100 different institutions.[3] Without such an organization 100 separate setups for each set of materials would be necessary.

Review by the curriculum committee in each discipline is very similar to the kind of review used by professional journals and case clearing houses but probably more rigorous. Certification means the materials are transportable and have been used successfully by others. If the national organization gains a reputation for certifying only high quality materials, the developers will receive professional recognition and hopefully rewards in the form of salary, promotion, and tenure.

CONDUIT Central is currently moving into a production phase in which it can collect usage statistics for developers to be given to administrators, and can also accept the responsibility of publishing smaller computer related teaching modules to be used to augment standard classes. Hopefully some of these modules will be available in the very near future and will bring professional recognition and encourage administrators to reward developers.

As a national organization, CONDUIT can advise funding agencies which are committed to improving the educational process regarding discipline areas that hold high potential for innovative approaches. Clearly, the impact of a national organization such as CONDUIT in reaching the untapped market could be strong.

## CONCLUSIONS

A successful approach to launching CRCM will require a central organization to take a total systems approach in directing and coordinating the efforts of the diverse groups which are needed to meet user and developer needs. The CONDUIT philosophy appears to meet the needs of users and developers and provides a form and organization for a national attack on the problem.

Because the needs and guidelines would not differ significantly, the untapped market could be any segment of the undergraduate population in basic courses.

A national organization cannot solve all problems, however. Faculty and professional organizations can promote a change in the posture of administrators toward developers. Computer centers must be service oriented toward users of CRCM if the untapped market is to be reached. In addition, there must be continued efforts to solve the transportation problems as curricula and technology change. In the long run CRCM will have to be validated in relation to several criteria for improving the educational process: learning, teaching, attitude of students, complex versus trivial problems, and so on.

The future looks bright; solutions are in sight. If colleges and universities continue to pursue the problems of exchanging CRCM, the growth stage of high mass consumption may be around the next corner.

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# Packaging and Repository Activities

**by Trinka Dunnagan**

As a result of two years of experience in program exchange, the CONDUIT project has identified problem areas and proposed solutions pertaining to the dissemination of educational software. This concern with program exchange has led to the drafting of three relevant products: the Review Rating Form; CONDUIT Documentation Guidelines; and Technical Transport Guidelines which are now being tested by the five regional networks and the curriculum advisory committees of CONDUIT. With these products, CONDUIT staff hope to regularize the process of exchanging computer-based educational materials by: encouraging developers to produce transportable instructional packages; increasing author recognition; providing a software dissemination mechanism; and supplying on-going program maintenance and support.

On the basis of CONDUIT experience with software dissemination, staff have developed several propositions which are now under evaluation.

*Programs should be reviewed initially by curriculum advisors and subsequently by CONDUIT faculty who use the materials in the classroom.* This review should encompass theoretical soundness, operational correctness, usefulness in the classroom and adequacy of the documentation and program as a curriculum package. For this activity, a Review Rating Form has been developed.

*Second, any deficiencies in a generally desirable package should be remedied at CONDUIT's instigation.* In addition, CONDUIT standards for transportability, as stated in the Technical Transport Guidelines, and documentation, as described in the CONDUIT Documentation Guidelines, should be met and the resulting program officially repositoried at a CONDUIT network center. This activity will, of course, be carried out only with the full knowledge and cooperation of the author.

*Third, the CONDUIT repository site, responsible for the program's transportability will convert the code to ANSI standard FORTRAN, if the program is batch-oriented, and to ACT transportable BASIC, if interactive.* CONDUIT transportability recommendations for structured programming, modularity and parameterization will be integrated into certified CONDUIT repository holdings. Providing sufficient information and procedures for program verification at any receiver's site is also a repository responsibility. In addition, the repository assembles for each program the components of a CONDUIT documentation package: a program abstract; an explanation of the program's educational content and use; a description of the technical aspects of the program; and instructions for its operation in the local computing center environment.

*Generalized products facilitate transportability.* To flag deviations from the standard, an ANSI standard FORTRAN analyzer is helpful. Also translation programs to go from FORTRAN to BASIC or vice versa and a standard tape transport format and code will facilitate transportability. Development of these types of generalized products has been made possible by CONDUIT's decision to adopt and test standards within the consortium.

Because of CONDUIT guidelines, the responsibilities of a repository center are fairly demanding. However, once a program is standardized, it can be easily moved to other centers. By knowing what is expected, both repository centers and receivers have been able to automate much of the exchange process. Preliminary indications are that cost savings will justify the one-time effort exerted by a repository center.

Figure 1 displays a first pass analysis of CONDUIT data on transportability. Because computer charges, clerical services and overhead are not taken into account, only curriculum coordinator and programmer time is included in total cost. By dividing the estimated lines of transported code into these dollar costs, staff have developed a rough figure of forty cents per line for program transport.

As illustrated by Figure 1 computer materials are not free even if distributed at no cost. Implementation can be costly. However by adopting transportability recommendations, CONDUIT hopes to reduce significantly costs to recipients of transporting computer-based instruction and, ultimately, to alleviate the overall problem of program exchange.

Figure 1. Time in $ in Transport Tasks

| Discipline | Dartmouth | Iowa | NCECS | Oregon State | Texas | Average |
|---|---|---|---|---|---|---|
| Chemistry (2)<br>(37 programs) | $2101 | $1048 | $2621 | $1744 | $1212 (1) | $1745 |
| Biology (4)<br>(20 programs) | -0- | 927 (1) | 608 | 810 | 288 | 658 |
| Physics<br>(Integrated package of small programs) | -0- (1) | 188 | 93 | 517 | -0- | 139 |
| Business<br>(20 programs) | 1565 | 820 | 680 | 1855 (1) | 275 | 1039 |
| Social Science<br>(9 data bases) | 320 (2) | 1640 (3) | 2379 (1) | 2685 | 1011 | 1607 |
| Economics<br>(4 programs, 1 data base) | 461 | 1008 | 1792 | 2401 | 231 | 1178 |
| Mathematics<br>(Integrated, 5 subroutines) | 192 | 288 (1) | 328 | 372 | 20 | 240 |

*Notes:*

1. Workshop and source site
2. Not complete package
3. NCECS workshop site; Iowa source site
4. Part of special distribution test, assigned to Texas and NCECS

# Chapter 18

## Hard Core CAI

### Hard Core CAI: A Progress Report

by James A. Schuyler

This chapter gives short progress reports on three of the "hard core" computer-aided-instruction projects currently under way in the United States, and compares their emphasis. Hard core CAI means computer uses in education in which specific interactive languages or systems of hardware are used which have been designed for this direct interaction with the student. CAI can be *contrasted* with uses of the computer as a tool, where the student does the programming, and with uses in which the computer contains canned programs the student uses to perform computations.

Three projects represented here have each contributed significantly to the effectiveness of CAI.

*PLANIT, transportability.* Charles Frye has developed a CAI language which is easy to use. The computer prompts the courseware author, hopefully reducing the cost of lesson preparation. Because PLANIT is written in a computer-independent form, a standard version of PLANIT can be shipped to a computer installation; and, once parameters related to the word-size and other characteristics of the computer have been set, implemented as painlessly as possible. A conference at Purdue University in 1973 brought together a large number of potential PLANIT users, with the aim of getting PLANIT implemented at most of the installations represented. The development of PLANIT is supported by the National Science Foundation.

*TICCIT, courseware authoring approach and student control.* Victor Bunderson, with his experience at the University of Texas as a base, is currently directing the implementation of the TICCIT system at Brigham Young University. A framework has been developed in which lesson materials (courseware) are created, tested and then disseminated. Because the objectives of each part of a lesson are structured, in modular form, students may choose a study route which makes sense for individual needs. The TICCIT system advises students when necessary, but does not enforce its advice. TICCIT uses television technology on a cable-TV system, and requires the use of very little special purpose equipment, hopefully making it a very low-cost system. It is also under local control, installed in junior-colleges, with final decisions about scheduling and courses made by the system's users. TICCIT is supported by the National Science Foundation.

*PLATO, new CAI hardware for a large-scale system.* Daniel Alpert represents the PLATO-IV system, whose totally new computer terminals were developed around the revolutionary plasma-display panel to provide flexible graphics, low-cost audio and student response via a touch-panel. A microfiche projector is included in each unit. PLATO-IV uses a super-computer to handle large numbers of terminals, as opposed to TICCIT's mini-systems. Authoring, on the other hand, is distributed among the individuals using the system, and most courseware is developed by faculty who need lessons for classes they are teaching. This does not exclude the possibility of large-scale or team efforts to develop courseware, and there are several such teams currently active. One of PLATO's previously unrecognized advantages is the capacity for student-to-student communications directly through the computer. This capability has created new patterns of teacher interaction as well, allowing wide-spread authoring groups to function by communicating thru PLATO. The development of the PLATO-IV system is funded primarily by the National Science Foundation.

Other CAI systems and languages seem primarily to provide existing techniques for CAI on other computer systems, with only a few really innovative approaches. Most of the innovative approaches have not been connected with the development of CAI systems, but have arisen as outcomes. The generative CAI approach is not discussed in this chapter simply because it doesn't currently seem to have the wide-spread potential and interest PLANIT, TICCIT and PLATO do.

The normal high-school, college or junior college is soon to be faced with hard decisions on whether to use Computer-Aided-Instruction or not, and, if so, about which of the available systems to use. A project at Northwestern University, called Computer Aids to Teaching, is attempting to evaluate (from the user's standpoint): the effects of C.A.I.; the costs of using various systems now in existence (including PLATO-IV); and the extent of support services a University must provide to its users. As a concomitant output, a CAI system called HYPERTUTOR has been developed which is upward-compatible with PLATO-IV, and can be used to transport PLATO-IV courseware. CAT is also the "sixth wheel" of the CONDUIT organization, with the responsibility to develop standards for documentation of hard core CAI lessons (or programs) and to then determine whether existing courseware can be adapted and transferred effectively.

In reviewing each of the three CAI projects described in this chapter, some questions must be thought through by users of CAI systems as well as producers.

First, it's obvious that everybody wants a low-cost system for CAI. The National Science Foundation is sinking millions of dollars into CAI projects, and they're shooting for roughly $1.00 or less per student hour at some future time, *not* this year or next year. If the hardware costs really do get that low, faculty and administrators finally will have to face the question of educational effectiveness of CAI. Educational Testing Service is evaluating the effects of PLATO and TICCIT, and users hope to see some hard data on how effective these systems are. However, most schools won't be using CAI as an add-on, since they won't be able to fire many of their teachers and go to the cheaper CAI systems. Previously one could have installed computers instead of hiring new teachers as the number of students was constantly increasing. However, in 1974 the demand for teachers is decreasing, and it is certainly a touchy subject to talk about firing teachers anywhere. One can certainly argue that CAI adds new dimensions to learning, but how can one convince the public that they ought to pay more for CAI systems in addition to what they're currently buying?

There is no hard data yet on how the teachers' and students' roles will be restructured by the appearance of CAI. Victor Bunderson's TICCIT is doing some restructuring by setting up courseware production teams and redefining the teacher's role, but nobody is really sure how the junior college faculty will react to TICCIT yet. Will teachers be able to effectively function within the computerized structure? What makes one think that the same people who are now teaching will be able to function in the new roles defined by CAI systems? Perhaps a totally different type of person will be needed.

Third, one must consider problems encountered in transfer of courseware. The TICCIT project approaches this problem head-on with an instructional development team approach in which specialists produce, validate and distribute courseware. On today's PLATO, hundreds of authors write their own lessons. It looks like democracy in action, but how does one know that the individuals' lessons will eventually be used? How does one determine whether a lesson is any good? If a teacher uses a lesson prepared by another person, will s/he be able to modify it, or must it be used in its original form? At the moment the transferrability of CAI seems to be hindered by language barriers. Will this change as PLATO-IV or TICCIT become the predominant CAI systems? What is the potential for PLANIT courseware?

Regarding validation CAI courseware isn't like a regular computer program, where all inputs are limited and can be anticipated. Local validation of a lesson by a single author which is too limited, is the rule in most cases today. Each lesson must instead be content-checked by experts in the appropriate discipline, then student-checked for effectiveness by several (or many) classes of students at several (or many) institutions.

Transfer of CAI, is hindered by the lack of effective documentation for almost all lessons. In part this happens because the courseware authors are simply exhausted when they finish the creation of lessons, and a demand for documentation, to be presented to potential teacher-users of their courseware, just adds one more task to their list. Such a function could be performed by an agency formed just for the purpose of validation of materials, but it remains to be seen whether users would be willing to pay for such a service.

These certainly are not all of the questions one could ask about hard core CAI, but they may be helpful in examining the effects of CAI further than just the glossy surface. CAI is a powerful tool which is rapidly approaching wide-spread use, and the questions posed above deserve answers in the near future.

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# Design Strategy for Learner-Controlled Courseware

by C. Victor Bunderson

Unlike other CAI systems which weight system design in favor of the biases of engineers and computer scientists, the TICCIT system is built around a coherent set of instructional principles, incorporated in a learner-control command language. In this paper some of the goals to be served by a CAI system are discussed, and the strategy using the command language, for achieving these goals described.*

## TICCIT

The TICCIT project (Time-Shared, Interactive, Computer-Controlled Information Television) has acted as a catalyst to bring together contributions from workers in CAI, instructional psychology, computer service, and systems engineering. The result is a system of hardware, software, courseware, and implementation strategies which has a number of novel features. Already the excellent digicolor display developed by the MITRE Corporation has begin to influence manufacturers, both directly and indirectly. The Sony color TV terminals (up to 128 can be drivenby two minicomputers), which provide for the display of free-form and computer-generated graphics in seven colors, videotapes, and digitized audio, represent a new alternative as low-cost display devices which have the capabilities needed for effective instruction.

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*The work described in this paper was conducted in large part under a subcontract from the MITRE Corporation, McLean, Virginia, under NSF.

Another contribution of the project which has already begun to prove its worth is the systematic courseware development procedure which is based on a separation of strategy and content, both conceptually and actually in the computer; and structure of the content files according to a taxonomy of instructional variables. The result is sufficient structure to organize teams with differentiated staffing, author training and component specifications based on prescriptive instructional theorems and management efficiencies. A commercial company has cross-validated some of these courseware development procedures in a major training project for the U.S. Navy, where cost-savings and increased effectiveness resulted in the development of materials, both for CAI and for non-CAI forms of media.

Other potential contributions of the project await the completion of the system software and implementation into Phoenix College and Alexandria campus of Northern Virginia Community College. An evaluation of the effectiveness of learner-control and an evaluation of the effectiveness of the content structure and implementation strategies in mathematics and English must await these developments.

The discussion of goals and strategies which follows is adapted from a more extensive publication, *The TICCIT Project: Design Strategy for Educational Innovation.*[1]

## EFFECTIVENESS GOALS FOR INDIVIDUAL STUDENTS

- *Mastery:* At least 85 percent of the students who take the TICCIT courses will achieve mastery, as defined by the mastery tests at the lesson and unit levels.
- *Efficiency:* Students will improve their efficiency in learning from CAI by a substantial factor as measured between the first two and last two units of any course. Efficiency as a design goal is expected to contribute to a decreased time of 25 percent or greater for students to complete, relative to classroom instruction. Time saving is of value to students, as well as to an educational system.
- *Improved Learning Strategies:* Learning strategies are defined operationally in terms of patterns of use of the learner control command language described in another section below. Improvement in strategies will be measured by the extent to which the student's efficiency improves simultaneously with the reduction in his requirement for advice.
- *Approach Rather Than Avoidance:* The students will develop a positive attitude of approach rather than avoidance relative to the subject matter in any TICCIT course. Attitude may be measured in part by questionnaires given to the student from time to time, but will be measured primarily by the extent to which the student will

voluntarily work on optional material and go on to take higher level TICCIT courses. The same type of measurement can take place in English and can be reflected at a gross level through increased enrollment in the more advanced English courses not taught by TICCIT.

- *Responsibility:* Students' attitude of responsibility toward learning will increase from the first unit to the last unit. While difficult to measure, it is expected that the extent to which students meet scheduled appointments can be assessed, as can the extent to which they exert continual effort toward achieving goals of mastery and efficiency.

The extent to which effectiveness goals for students are achieved is very much a function of the learner-controlled courseware concept described below. Rather than being led step-by-step, a student is given a command language which allows him or her to survey freely, establish an individual sequence within the constraints set by prerequisites, and establish learning tactics. Learning tactics are described in terms of the sequence of rules, examples and practice instances a student sees. It is only through this learner-control strategy that TICCIT can help the student achieve improvement in all five of the effectiveness goals.

*Mastery.* The strategy to achieve the goal of student mastery is based on the application of instructional theorems to the design of a modular courseware data structure. This data structure, or content structure, is separated both conceptually and physically in the computer from the logic which implements instructional sequencing strategies. Instructional sequencing strategies are largely left in the hands of the student, who is guided by an advisor program to develop individual characteristic strategy and tactics.

Instructional research, and propositions or theorems derived from it, shaped the design of the content components. These propositions are described in Merrill and Boutwell[2] and Merrill[3]. In the former paper, a review of the literature on learning and instruction led to the development of a taxonomy of instructional variables of three classes: presentation form; inter-display relationships; and mathemagenic information. By means of this taxonomy, any instructional sequence involved in complex cognitive learning tasks may be characterized.

Presentation form may be of four types, generalities or instances, either of which may be presented either in expository on inquisitory form. The system deals primarily with concept learning and rule using, so a generality is a definition of a concept, or a clear statement of a rule. An instance is an example or non-example of a concept or a rule in use. Inquisitory generalities (e.g., "define a concept") are rarely used in TICCIT, since memorization of rules is not sought and since open-ended definitions or rule statements in natural language are difficult to analyze by computer.

Mathemagnic information involves prompting and cuing and other attention-focusing techniques. Specific techniques include: attribute isolation (use of color, graphics, etc., to highlight key attributes); search strategies (step-by-step algorithm); mnemonic aids; and production strategies.

Certain concepts of man-machine instruction developed at the University of Texas Computer Aided Instruction laboratory were combined with the Merrill taxonomy to devise the modular courseware structure. These included the concept of hierarchically indexed data structures and a command language to move about within these structures. A set of content files indexed within these structures was defined. Since the content files were developed along the lines of the taxonomy of instructional variables, students could use the command language to sequence these files themselves, thus manipulating instructional variables.

The TICCIT courseware is hierarchically organized into four levels represented to the student by special displays that: present the hierarchies; list the topics; provide access to a standardized version of the objectives; and display status after the student has worked. Levels are:

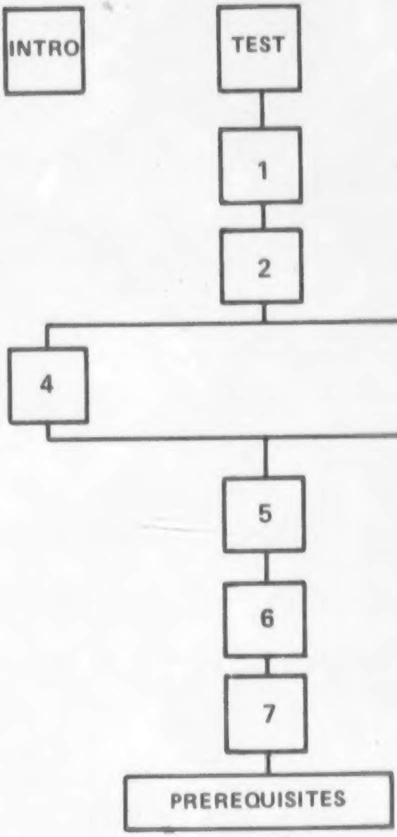
- *Course Level:* Course objectives and status display (course map);
- *Unit Level:* Unit objectives and status display (unit map);
- *Lesson Level:* Lesson objectives and status display (lesson map); and
- *Segment Level:* Primary Instruction Components (rule, example, practice).

## OBJECTIVES AND STATUS DISPLAY

A simplified map is shown in Figure 1. The screen displays a hierarchy on one side and topics on the other. To survey, the student may look at the introduction (either a minilesson, a sequence of digitally generated displays, or a videotape) or may type integers, or may type "P". Typing an integer followed by the OBJ (objective) key gives a cartoon illustrating the segment objective. "P" gives the prerequisites. STATUS is indicated by coloring the boxes red, yellow or green to indicate trouble, uncertainty, or clear progress. Typing "X" gives a similar map for extra optional material, including AB work, games, simulations and other "fun options."

At the course level, the boxes represent unit objectives. At the unit level, they represent lesson objectives, and, at the lesson level, they represent segment objectives. To permit the student access to any level of the courseware, a learner control command keyboard was designed. (See Figure 2) The ATTN key signals that a typed command is forthcoming (e.g., logon, logoff, calculate). BACK displays the immediately preceding screen image. SKIP permits by-passing a test item and certain other functions. NOTE records a comment for the author and EXIT pops back to a level from which the student exited for some operation. The nine keys

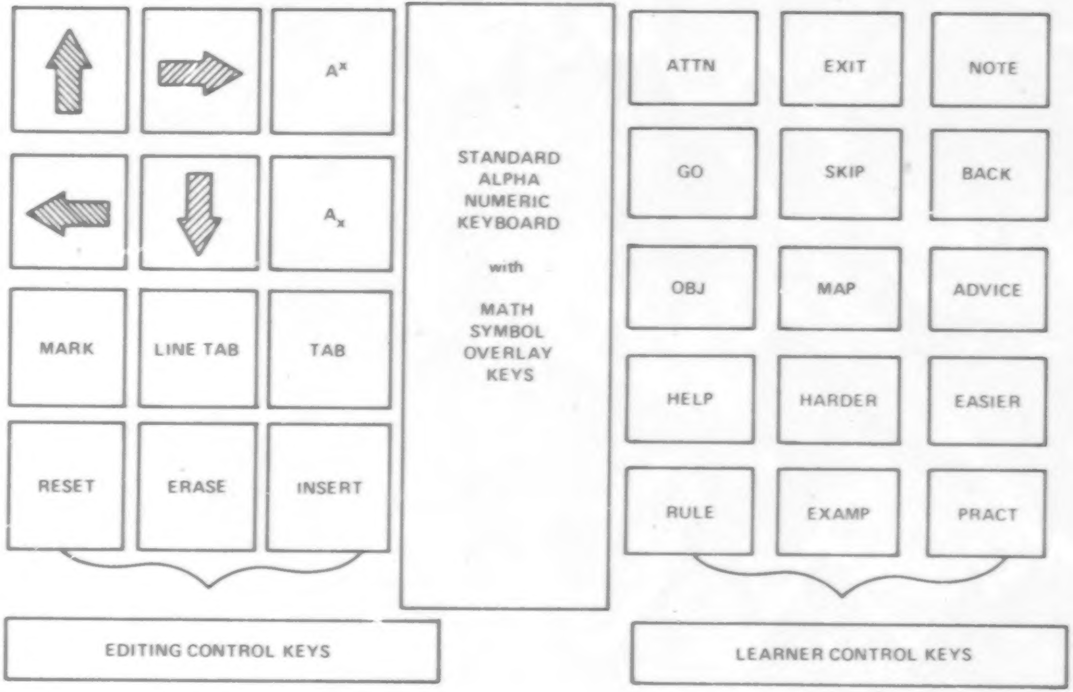
Figure 1. Lesson MAP


INTRO
TEST
EXTRA
1
2
4
3
5
6
7
PREREQUISITES

E.8.5

1. The Complete Verb Phrase
2. Uses of the Verb "to be"
3. Memorizing Be Verbs
4. Recognizing Have Verbs
5. Recognizing the Modals
6. Memorizing Modals
7. Identifying Verbs

Figure 2. TICCIT Keyboard


$A^x$
$A_x$
MARK
LINE TAB
TAB
RESET
ERASE
INSERT
EDITING CONTROL KEYS
STANDARD ALPHA NUMERIC KEYBOARD
with
MATH SYMBOL OVERLAY KEYS
ATTN
EXIT
NOTE
GO
SKIP
BACK
OBJ
MAP
ADVICE
HELP
HARDER
EASIER
RULE
EXAMP
PRACT
LEARNER CONTROL KEYS

at the bottom of Figure 2 are involved in the learner's control of his own learning tactics. The **RULE**, **EXAMP**, **PRACT**, **EASIER**, **HARDER**, **HELP**, and **OBJ** keys deal with events within a segment while the **MAP** and **ADVICE** keys are more general.

On a course or unit map when the student selects a box, s/he pushes the GO button and drops to the next lower map. On a lesson map, when the student selects a segment, s/he pushes the **RULE**, **EXAMP** (example) or **PRACT** (practice) button to interact directly with the content. Following any of these three buttons, s/he may push **EASIER**, **HARDER**, or **HELP** to vary the instructional variables which s/he may require for effective learning.

From the lesson map illustrated in Figure 1 and from the primary instruction keys, the various content files which compose the modular courseware data structure may be inferred.

The three main primary instruction learner-control buttons are related to the presentation form dimension of the taxonomy of instructional variables as indicated in Figure 3. This figure also shows how the **EASIER** and **HARDER** keys are related to inter-display relationship variables, and the **HELP** to mathemagenic information.

The function of the nine principal learner control command keys is as follows:

- *RULE.* Accesses the main generality for a segment. For a concept, this is a definition; for a rule, it is a clear statement; for memorization, it is a description of what is to be memorized.
- *EXAMP.* Accesses the next instance in a file of expository instances. The sequence of instances is constructed so that matching, pairing, and other instructional variables, not appropriate for student control, are built in.
- *PRACT.* Accesses the same instance file as **EXAMP**, but presents it in inquisitory mode, with necessary answer processing for student-entered responses.

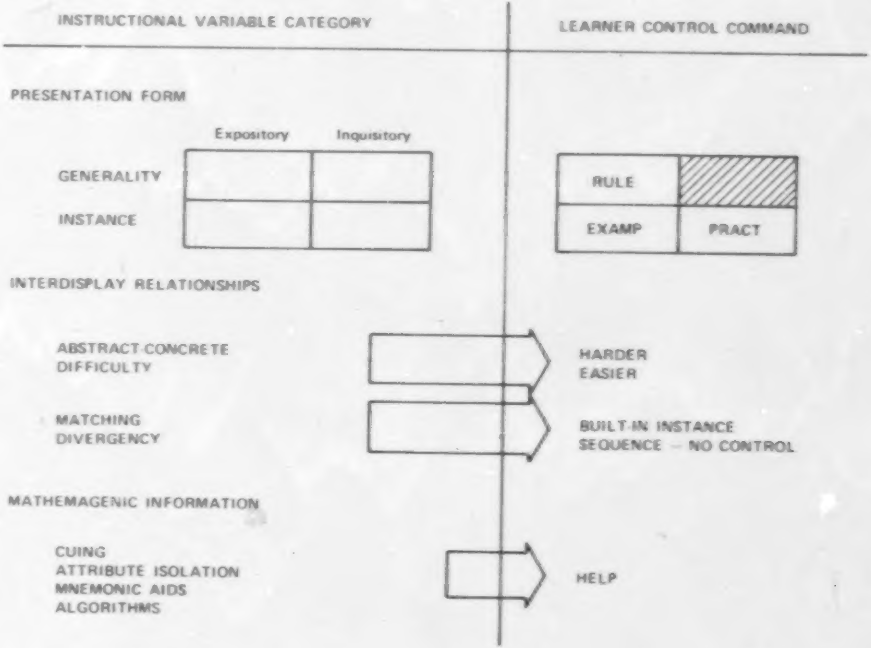
RULE may be followed by:

- *EASIER.* More concrete form of rule (an analogy). Simpler terminology.
- *HARDER.* More abstract. Technical notation and terminology.
- *HELP.* Mnemonic aids to remember the rule. Attribute isolation of key terms or characteristics using color, graphics and audio. These displays may be followed by an information processing sequence for using the rule or testing instances of the concept.

PRACT or EXAMP may be followed by:

- *EASIER* or *HARDER.* Shifts to easier or harder instances.
- *HELP.* Instance specific attribute isolation using color, arrows, sometimes graphics and sometimes audio. Aids to recall the rule are presented first, followed by a step-by-step walk-through of a good

Figure 3. Relation of Learner Control Commands to Instructional Variables


INSTRUCTIONAL VARIABLE CATEGORY
LEARNER CONTROL COMMAND
PRESENTATION FORM
Expository
Inquisitory
GENERALITY
INSTANCE
RULE
EXAMP
PRACT
INTERDISPLAY RELATIONSHIPS
ABSTRACT-CONCRETE
DIFFICULTY
HARDER
EASIER
MATCHING
DIVERGENCY
BUILT-IN INSTANCE
SEQUENCE – NO CONTROL
MATHEMAGENIC INFORMATION
CUING
ATTRIBUTE ISOLATION
MNEMONIC AIDS
ALGORITHMS
HELP

information-processing algorithm for using the rule or testing the concept, specific to this instance.

Matching of examples and non-examples and a default sequence generally going from easy to hard and covering the necessary range of divergency among the instances is built into the instance files and their controlling logic. A guiding principle in the design of learner control was that students should be given control only over those variables for which they had a basis for intelligent choice.

There are five basic kinds of content files, with additional files for display formatting and answer-processing. Map files include the objectives and prerequisites for survey, and the INTRO content for course, unit and lesson maps. Generality files provide for each segment a main generality, an easier version, a harder version and a "help" file for the generality. For each segment a sequence of twelve to forty instances are included in the instance files. Instances are classified as easy, medium and hard and are available in expository or inquisitory modes. For each instance, a help file specific to that instance is available. In inquisitory mode, answer-processing and feedback is available. Instance files may be defined by generative algorithms as well as by a set of discrete items. Test files for each lesson are made up of instances similar to those found in the inquisitory instance files. On the XTRA map AB level tests are optional. Although they are often off-line, unit and course level tests may be provided.

Fun options are games, simulations, tidbits of humorous or interesting information, and options to look at extra videotapes of interests. These are made available on the same map with any AB level work, to induce students voluntarily to choose optional work. The learner-control command language provides the student with a means to access any file with few restraints. Although the student may be forced to listen to and look at advice if s/he is going astray, s/he is never forced to look at any instructional material.

Each student has an idiosyncratic requirement for instruction on the various objectives which constitute a course. Through the map displays and through the status reports using this map display, s/he can select objectives and, within broad restraints set by the prerequisite relationships between lessons, the sequence of those objectives. Within an objective, which typically teaches a single concept or rule, students vary as to the amount of help they need to understand how to perform on the practice items which test that objective.

Slower students will need more EASIER displays, more HELP, and a greater number of instances. Brighter students may use a discovery approach, focusing on the harder practice instances. They will have fewer requirements for HELP and for the alternate rule displays. Status reports tell the student when s/he has achieved mastery, so any student can read the displays and be assured of eventually reaching a mastery state.

*Efficiency.* The careful analysis of content into learning hierarchies typically increases the efficiency of systematically designed instruction in comparison to classroom instruction, since incidental material is deleted. Furthermore, students can skip those objectives which they already know. At the level of the tactical sequences of primary instruction keys within a segment, TICCIT also hopes to improve efficiency. The advisor program and status displays constitute the design techniques used to achieve this goal. It is expected that learner-control will be less efficient, at first, than would a skillfully designed adaptive sequence based on research and controlled by the computer. However, given adequate status displays, a reasonably good advisor, and practice, students should be able to develop skill in strategy and tactics which will exceed the efficiency possible through program control.

*Improved Strategies.* Even if the art and science of mathematical modeling of the learning process should evolve to the point where greater levels of mastery and efficiency could always be obtained by computer control than by learner control, learner control would be preferred. The goal of improved strategies and its companion goals, improved attitudes of approach and responsibility, should not be subordinated to the quest for efficiency.

Previous research on learner control at the University of Texas[4] did not seek to establish relationships between the availability of learner control and the growth in strategy competence, approach and responsibility. The conception of learner control was too narrow, both in relation to the outcomes of learner control and the means to implement it. Available CAI programs were too short in duration for much skill in learner control to develop, and the courseware data structures lacked the modularity and the relationship to instructional variables inherent in the TICCIT courseware design.

A broader concept of learner control requires better answers to the questions: What is to be controlled? How is it to be controlled? On what basis do we expect the student to learn to control it? The student should have control over instructional variables which can make a difference in his or her learning. In the TICCIT project, variables reviewed and classifed in the paper by Merrill and Boutwell (1973) were divided into those which could readily be manipulated by the student and those which, at least for now, should remain under the control of the authors and the computer. The results of this decision process are described above in the discussion of the MAP logic, and the primary instruction commands.

How are these variables to be controlled? Earlier learner control researchers had relinquished control to the student in a fairly ad hoc and non-systematic manner. Because of the lack of separation of strategy and content in the various tutorial CAI languages, choice of options was thrust unexpectedly into the hands of students at content specific decision points. A more rational approach was developed in later years[5], but all these approaches were still limited in the range of variables placed under student control. The TICCIT design for learner control viewed student-machine interaction as a communication process requiring a formal command language related to the variables which affect learning.

A model for student-machine communication developed by Pask[6] provided one source of inspiration for the learner control command language implemented in TICCIT. Pask asserted that all communication between student and computer can be described as taking place in one or more special languages. The flow of instructional information sequenced according to fixed algorithms within the computer, and the answers to questions and problems entered by the student comprise what Pask calls the $L^0$ language. Discussion about the instructional process itself, and attempts by the student to control the process in some way, take place in $L^1$. It is possible also to define an $L^2$ language in which control processes can be discussed and modified.

In the TICCIT system, progressively higher levels of discourse are used which are analogous to Pask's languages. Level 0 may be implemented primarily within the files of instances where students may look at worked examples or may practice. Level 1 is implemented by means of the MAP logic and the primary instruction keys. Level 2 is implemented by an advisor program, which refers to a set of student historical data (monitor) and communicates by reference to "status displays" at course, unit, lesson and segment levels. The advisor also communicates through audio and through blue-colored visual displays.

The concept of a learner control command language and advisor which permits discourse between students and machine at all three of Pask's levels is the key element in the design approach for improving student strategies. The elements missing from earlier implementations of learner control were the instructional variable-related commands, the status displays and the advisor.

These latter elements provide an answer to the question: "on what basis may the student learn improved strategies?" Given instructionally relevant commands, well-defined goals (objectives and tests on MAP displays), and status reports which reveal the discrepancy between present status and desired status, students have the information necessary to initiate strategic and tactical decisions. The availability of an advisor permits the student to request suggestions on which strategic or tactical decisions might be appropriate at any time during the process of instruction. The advisor also monitors the student's choices and offers unsolicited advice about strategy or tactics when the student departs from a generally useful model.

Learner strategy has four phases: survey; learning tactics; evaluation; and review. Maps at the course, unit and lesson levels, permit access to: the introduction, videotape or minilesson; the objectives; the prerequisites; and any rule display. The student may survey any unit and lesson in the course freely, but s/he may not work on instances or tests on any lesson for which s/he has not completed the prerequisite lessons. MAP, GO, OBJ, INTRO, PREREQUISITES, and RULE commands can be used to survey.

Learning tactics occur within a segment, and use the primary instruction commands RULE, EXAMP, PRACT, EASIER, HARDER, and HELP in any sequence, except EASIER, HARDER, or HELP must always be preceded by RULE, EXAMP, or PRACT.

Testing tactics take place in the practice files for self-testing, and in the lesson and unit tests where students get three attempts at the lesson-level working tests. The students with higher aspirations or with greater approach responses may, on certain lessons, type XTRA to access another MAP with fun options and more advanced concepts and rules. An AB level test may be provided on the XTRA map, for which only one attempt is permitted.

Review tactics are permitted at any time. Within a lesson, review mode is identical to initial learning with the exception that no scoring occurs and the advisor is limited to a few simple, general comments about review strategy.

*Approach vs. Avoidance.* What variables effect positive affect toward learning a particular content? One point is clear: It is impossible even to measure approach without permitting free choice. Voluntary choice is a requisite for the measurement of an affective objective[7].

The designers of TICCIT hypothesize that learner control will also contribute to the development of approach responses. Because the XTRA menu and the AB level test are strictly voluntary, the extent to which students spend time on these materials is one indication of the growth of approach responses.

Effective instruction may be the most powerful variable in producing approach. A sense of accomplishment, and a recognition of growing skill at strategy and tactics may lead the student to choose optional work during TICCIT instruction and more significantly, to elect more advanced math or English courses not using TICCIT. Introductory videotapes and minilessons are also designed to produce a positive attitude toward taking each TICCIT lesson. In addition, the use of color, graphics and low-key humor are designed to lighten the task of learning.

*Responsibility.* Like approach, the growth of a sense of responsibility is an outcome for which the controlling variables are not well understood. The modular design of TICCIT with its clearly defined outcomes of mastery and efficiency, provides an opportunity to observe variations in indices related to responsible use of time and resources. The extent to which appointments are scheduled and kept provides a gross measure. Day-to-day fluctuations in efficiency provide a more fine-grained measure which should be explored.

The design strategy is based on the assumption that growth in responsibility occurs when responsibility is clearly fixed and help is provided to assist the individual to carry that responsibility. An over-riding tone pervades the courseware and the advisor program. It says wordlessly that the responsibility of the authors is to provide effective, interesting instructional resources, and helpful advice. The responsibility of the student is to select individual own goals, (at registration); to plan a sequence of subgoals; and to apply himself or herself actively to the task of achieving those goals.

The training of proctors and teachers is a key aspect in the strategy to achieve improved responsibility. Teachers and proctors must learn not to step in and rescue a student from an impending error, but instead maintain a problem-solving nonjudgmental attitude and provide help when requested.

In summary, the design strategy for effective goals is based on a review of instructional variables effective in complex cognitive learning, particularly in concept and rule learning. Certain of these variables were put under the control of the student by means of a learner control command language. The student uses this language to: survey the course; plan an overall sequence strategy for learning objectives; develop specific learning tactics for each objective; and develop his or her own testing and review tactics. Status displays help the student focus efforts and make strategic and tactical choices. An advisor program helps him or her learn the command language so that strategies and level of mastery and efficiency will improve simultaneously. In addition, improved attitudes of approach and responsibility are sought through global aspects of the courseware design and through the manner in which teachers and proctors are expected to interact.

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# The PLATO Project: A Status Report

**by Daniel Alpert**

This paper does not try to evaluate the PLATO project, nor to compare it with any other system; rather it sets forth my personal appraisal of the status of the project today, and discusses the prospects for widespread dissemination of the PLATO system tomorrow. The Computer-based Education Research Laboratory at the Univesrity of Illinois at Urbana-Champaign is about to embark on a demonstration field-test and formal evaluation of the system. The demonstration program is jointly sponsored by the National Science Foundation and the University of Illinois, and a formal evaluation will be carried out by Educational Testing Service.

The dissemination of a new technology, which some have called the technological innovation process, involves two major phases: technological research and development, including exploratory research, invention, systems development, and demonstration of technological feasibility; and large scale marketing and production. Widespread acceptance by individual and institutional users and the development of economic feasibility usually is a result of sizeable investment capital and mass production. In any field, these steps are characteristic of the introduction of technological innovation, and the second phase, upon which the PLATO project is now embarking, is typically far more expensive than the first in terms of effort and dollars.

## PLATO IV

PLATO IV was designed not as a research tool, but as a prototype of a widespread people's technology to permit instructors and students to transform teaching and learning into exciting sports. The system design was based on the premise that the existing technologies currently in use in schools, both the tools and the ways of doing things, are inadequate and obsolescent. Tools, that have been in use for centuries, include the printing press, the classroom, and the textbook; and ways of doing things include lectures, lock-step schedules for all students, and multiple-choice examinations. In general, these technologies are deficient in three critical ways:

- They are based on a one-to-many teaching strategy; that is, they make learning a spectator sport.
- For economic reasons, the lecture and the textbook must be addressed to an average student, a person increasingly hard to find in a world of increasing diversity.
- The existing technologies do not provide adequate feedback to either the learner or the teacher, so that what we will do tomorrow can not be substantively improved as a result of what we did yesterday.

The PLATO IV system is built around the following components, each of which involves new technologies:

- A large central computer serving at least 1,000 student consoles.
- A major new author and user language called TUTOR; every student console can be used by authors and instructors to write, edit, and modify instructional materials and to acquire and process student performance data.
- A new student console based on a number of new technologies for displays; these include a new graphics display with built-in-memory, the plasma display panel, a random-access microfiche image selector, and a touch panel by which either students or authors may communicate with the system by simply touching the display.
- New communications techniques that make possible a geographically distributed network; any console can talk to, or monitor, any other student console.

A wide variety of instructional strategies and subject matter areas is incorporated in the instructional materials that have already been prepared for the PLATO IV system; for example, these include a course in Chinese, in which Chinese characters can be locally stored in the student console; elementary mathematics, in which two students may play games at the same console or at different consoles; and biology, in which the genetics of fruit flies are built into a simulated genetic model, permitting students to carry out actual experiments that used to be carried out in the genetics laboratory. In addition, PLATO IV provides instruction in chemistry, physics, veterinary medicine, and many other subjects at all levels. In total there are 1,500 hours of instructional materials completed in about 50 course areas.

The PLATO IV system has now been in operation for almost two years. In April 1974, there are about 450 student consoles connected to the CDC computer in Urbana; most of the terminals are located in the state of Illinois, but almost 100 are distributed elsewhere in the country, from California to Washington, D.C. The laboratory is still adding consoles and expects to have more than 800 on the system by the end of the year. Currently providing reliable access to all consoles during available prime time between 8 a.m. and 10 p.m., the system is operating with unscheduled downtime less than 5 percent of the time due to all causes. Thus, the system provides about 120,000 contact hours per month to at least 40 institutions, including about 10 institutions with at least a dozen consoles.

Despite the fact that a great deal of instructional materials have been written for use on PLATO, there is still great need for additional curricular development. At the present time, over 600 authors are logged into the system, and at least 30,000 hours per month devoted to authoring on-line. This does not include time devoted to student-testing of materials, a critical part of the development and validation process. Currently, there are well over 50 courses in the process of development or revision, including some of those which will be field-tested in September.

The most significant status report about the system is that it is up and running! The system is operating as a CAI and CMI system with hundreds of students and authors on line, and it is operating as an effective inter-institutional interstate communications network, with teams of authors, users, consultants, and instructional designers working on common problems and exchanging ideas and information in a completely unprecedented way. In short, not only has the technological feasibility of the PLATO IV system been demonstrated, but there is a remarkable culture in the process of development; major changes are taking place among authors and users of PLATO which are difficult to summarize or record. I do not want to imply that there are no problems associated with the system. However, the first phase of the innovation process, the demonstration of technological feasibility, has been accomplished.

How about the second phase: widespread cultural acceptance and feasible economic costs? Obviously acceptance and economics are not independent of each other. For this reason it has always been an underlying premise of the PLATO IV systems design that, in order to gain wide acceptance, the unit cost of instruction on the PLATO system would have to compare favorably with the unit cost of instruction at any educational institution. In our initial statement of target costs for the system[1] two assumptions were made: the system would be in instructional use 40 hours per week, or 2,000 hours per year; and capital investment in hardware would be amortized over a five year period. We presented a target cost of about 50 cents per contact hour to cover the costs of the computer, student console, communications and systems management, and the communications estimate over a maximum distance of 150 miles.

What are the actual current costs of PLATO IV? When a project is at the developmental stage, and the persons operating the system are also building, improving the system, it is not easy to separate the start-up developmental costs from the ongoing operational costs. For this reason, one might get varying estimates from different persons familiar with the PLATO project, and the following cost estimates are my own. Current computer costs, if extrapolated to a fully loaded computer (i.e., serving 1,000 consoles), would be 60 cents per contact hour, including an expansion of the memory. The current cost of the student console is approximately $6,000, including the random-access image selector and the electronic touch panel which brings the unit costs of the console also to approximately 60 cents per contact hour. The cost of communications shows the greatest disparity from our original estimates, due partly to the reluctance of the telephone system to permit PLATO to use ETV video channels. Using regular telephone lines, each serving 4 student consoles, communications costs are about 30¢ to 40¢ per contact hour for consoles at a distance of 150 miles (the distance from Urbana to Chicago). Finally, the cost of operation and maintenance of this system, still in its developmental stages, is about 10¢ to 25¢ per contact hour. Thus my estimate of the total unit cost is about $1.50 to $1.85 per contact hour (not including instructional materials).

At this price level the capital investment needed is so high as to discourage the widespread use of the system by educational institutions in the near future. However, many schools and colleges could readily justify an investment in PLATO if the costs were reduced by a factor of three. Thus, in economic terms, PLATO faces a chicken and egg situation: we could justify many more PLATO installations if the costs were about one-third of what they are, and the costs could probably be reduced by a factor of three if there were a sufficient market for the system.

Suppose the economic boundary conditions could be met. Would there be a market in existing educational institutions a ground swell of enthusiasm for access to the system, if it were available at the target costs? While I have confidence in the eventual outcome, I would have to say in all candor that, as of today, the marketing would face many uncertainties. Originally, the PLATO project started out to show how PLATO IV could be used on a major university campus and to branch to other institutions as opportunities arose. However, sponsors asked the laboratory to carry out the field-test and evaluation at several community colleges (four in the city of Chicago) and elementary schools. Thus, in a very short time frame, we have had to learn how to work with people in other institutions to prepare appropriate instructional materials for use in these institutions and, in the process, we are learning how these institutions work. To move off campus is in many ways much more difficult, especially in institutions where there is no tradition of curriculum development by the instructional staff or of released time for such activities. It will surprise no one to learn that instructors will accept a new medium, but not if it threatens to take their jobs away or to serve purposes which they do not understand.

To incorporate a new medium like PLATO, a continuing process of social invention has been necessary and will continue to be necessary both to set educational objectives and to develop procedures for writing, editing, and validating instructional materials. It has been necessary to develop teams not only to design instructional materials but also to build an infrastructure that can manage the adoption of a new medium. Teams have included people from different institutions, and carried out different functions: authors; instructional designers; test and evaluation specialists; and TUTOR programmers. Also included in such teams are instructor/users who may not actually program PLATO lessons, but who do know the students and their aspirations and take part in the planning and criticism of the instructional materials. These teams are inter-institutional and involve people from several different community colleges or public schools as well as from the university.

We are developing new insights as to the product and the process and are building a new concept for computer-assisted instruction and computer-managed instruction. Rather than follow the usual narrowly prescribed concept of using CAI to support the traditional curriculum and teaching process, the PLATO IV system makes it possible to change and to enlarge the curriculum and to modify the roles of the humans responsible for the instructional process.

Designing valid CAI objectives and transportable curricular materials is an area in which the CAI community had made little progress. I believe that the backward state of this art is due to the backward state of previous CAI and CMI systems. Until PLATO IV, there has not been a CAI system that permitted the true interaction of a wide variety of people and perspectives. With PLATO, one has not only a very flexible hardware system but also a powerful authoring and user language, TUTOR. In my view two characteristics of the PLATO IV system are essential to the development of a widespread computer-based education effort in this country. First a communications network that encourages the development of inter-institutional exchanges of ideas and criticism, as well as inter-institutional cooperation is necessary for the development of a true culture even on a single campus. Second the capability of the PLATO system for acquiring and processing student performance and teacher-author performance data is critical for the dissemination of CAI at least in the early stages of the use of the system. While a powerful authoring language, graphic displays, and other exciting features are also very desirable, these two features are essential to the development of widespread involvement in and use of a CAI system. Indeed, if someone could build an economical free-standing minicomputer to do the instruction, I believe that it would be necessary to tie many of them together in a PLATO-like communications network to develop a sufficient culture for disseminating the system and for providing compatibility between systems.

## CONCLUSION

I believe that the large community now using PLATO IV has come a long way toward demonstrating feasibility of a major new educational medium. However, the acceptance of such an instrument depends on continuing social invention: the development of institutions and procedures that will provide the instructional strategies, the curricular materials, and the new ways of doing things that will be necessary for putting the new technologies to work.

While the PLATO IV users community is gradually developing these mechanisms, we have a long way to go. In introducing a major new technology, it is necessary not only to recognize what must be done but to understand the scale at which it must happen if it is to make a meaningful contribution to American educational institutions. Studies have shown that the technological invention and feasibility stage represents only a small fraction, perhaps 10 percent, of the efforts and dollars needed to place a new technology into operational use. To make PLATO a success in terms of widespread dissemination, a major additional investment in terms of dollars and commitment will be necessary. However, even such an investment is very small in the context of a national expenditure for education of $60 billion annually.

I believe that what we are not doing as educators is simply not adequate for the education of our citizens or for the survival of our institutions. Our educational programs, lack practical feasibility and a theoretical framework for the teaching-learning process. It is for these reasons I retain a commitment to the development of a national computer-based network for education: one that is also capable of developing a national community of research effort, both in the applied fields of instruction and in basic research on the teaching-learning process. Such a community does not now exist; and it may never exist if educators restrict activities to the use of instructional technologies that are inadequate not only as means for teaching but also as means for learning about the teaching process.

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# PLANIT: The Portable CAI System

**by Charles H. Frye**

In 1968, I chaired a panel for an AERA convention in Los Angeles on "CAI: A Five-Year Perspective." Vic Bunderson was on that panel, and although the TICCIT work was not yet initiated, it was foreshadowed by early work at the University of Texas. The PLATO project was represented there by Don Bitzer who brought along a four-inch square panel of glass on which he could light the letters, "UI." Arthur Melmed was there from the National Science Foundation giving his observations regarding the Foundation's long-term interest in CAI, which is now being overseen by Erik McWilliams. His office has provided a substantial amount of the funding for CAI development including much of the support for PLATO, TICCIT, and PLANIT. One thing the development of CAI has not lacked is continuity.

A prototype of PLANIT was put into operation early in 1966. With it one could author and dispense typical CAI lesson scenarios with particularly good facility in numerically-oriented lesson materials. Five years ago the PLANIT group was proposing a machine independent operating system for CAI that could easily be installed on any garden variety computer hardware and be used to implement the PLANIT language in time-shared fashion for authoring and dispensing CAI. In contrast to the prototype PLANIT, the new portable version was to be a complete system including all the necessary pieces for production CAI. To include only a lesson authoring and execution capability would hardly qualify to be called a system in the terminology of most computer centers' personnel. They also want such capabilities as: file maintenance and backup; program maintenance; user accounting; device allocation; and so on. Thus, PLANIT is much more than just a CAI language.

Five years later in 1974 the proposed PLANIT system has been completed and is being tested in the several sites where it has been installed. This paper reports on that progress and offers some comments on the relationship of PLANIT to PLATO and TICCIT.

Confidence was lacking at the outset that the development of a truly portable CAI system could be achieved. One widely respected systems expert gave the project less than ten percent chance of success. Others said that PLANIT would not be alive at the end of the five-year period. It is to the credit of National Science Foundation staff that they continued to believe that the goal was attainable.

By 1974, PLANIT has been installed on a wide variety of hardware, including CDC 3170, 3300, and 6500, DEC 10, Honeywell 200 and 600, IBM 360/40, 360/67 and 370/155, Siemens 4004 and 4004/155, Telefunken, Univac 1108, and XDS 940, some under existing time-sharing systems and others under batch. One version runs side-by-side with a spooling system, HASP. It was promised that PLANIT would run 20 terminals in no more than 256,000 bytes of core. It is now running more in less space. In at least one case PLANIT ran 12 terminals in 72,000 bytes of core. Being completely modularized, it can be configured to the core that is available.

PLANIT installation cost was promised to be in the range of $10,000 to $20,000. Recently Purdue University completed a study in which PLANIT was installed on their CDC 6500 and run for a week long pilot study during which 56 PLANIT users ran an average of 49.8 minutes each. They reported a total installation cost of about $1300 requiring about 147 hours of programmer time. Others have also confirmed that the original cost estimates for installation were unnecessarily high.

On the question of consumptiveness, Purdue reported several statistics based on their pilot study:

- *Throughput was apparently unaffected by the operation of PLANIT.* Average jobs per hour for the week of the pilot study was 434 compared to an average of 421 for the week prior and 445 for the week following.
- *PLANIT required approximately 1/5 of available core* while it was processing a user, consuming an average of 4.15 seconds of CPU time per 50-minute period (reflecting the expected low CPU usage for CAI).
- *Terminal/hour costs ranged from $2.08 to $2.25*, using Purdue's standard charging algorithm.

It has been observed that because PLANIT uses FORTRAN in the installation process, the result must surely be inefficient especially since such a simple subset is used to implement complex system functions such as scheduling and cataloging. While it is true that machine language would run faster, two advantages outweigh the disadvantage inherent in the use of FORTRAN.

First, contrary to all other transfer methods short of recoding, PLANIT execution efficiency will not suffer when the system is moved from one computer to another.

Second, typical CPU usage is very low for CAI such that small differences in efficiency will have only marginal effect. There is no efficiency loss in use of space and peripherals where the CAI investment is high.

At one site in particular there is little doubt that PLANIT is being used as a production system. The University of Freiburg in West Germany has been using it in that fashion for more than a year with a daily operating schedule, courses taught for credit, and authors hired full-time. Being first, they experienced more than their share of problems but they report the system has operated quite reliably for the last several months.

The PLANIT system is designed as an interpreter. Lesson material is stored internally in original typed (or keypunched) form and the keystroke characters are deciphered as the lesson is dispensed to students. Although the use of interpreters is often justified only because the developer didn't know how to build a compiler, there are some applications such as CAI where the advantages of an interpreter outweigh its disadvantages.

*Interpreting allows certain options in the language which would be difficult or impossible to compile.* Since CAI is normally concerned with a user community which is new to computing, the concept of compiling prior to execution will be a new one. Compiling tends to encourage the adoption of language conventions aimed at easing the compilation task at a cost of user convenience. For example, many languages use counter items to code user response paths because they can more easily be used in later decision points. Many aspects of PLANIT take on a definition only after the student responds (too late for efficient compilation).

*Although compute times are greater for interpreted programs than for compiled programs,* ranging from a little greater for character shuffling to more than a hundred times greater for number crunching, much of CAI is character shuffling and compute times are characteristically so small that they are not usually a significant factor.

*Space will usually be of more concern in CAI applications than time.* Since a compiled program grows in size according to the number of source statements while an interpreted program usually operates in a fixed size, there will be a point beyond which the compiled program will be the largest. (Source code is normally more compact than compiled code.) CAI programs are typically large (as programs go) and will pass that point very quickly. Add the fact that most compiling systems also retain the original source code for editing purposes causing still more space to be consumed.

In general, space will probably be more costly to CAI than compute time and interpreting systems will normally require substantially less space. The PLATO terminal has the microfiche projection capability which alleviates this problem to some extent but raises the preparation costs somewhat.

## PLANIT VS. PLATO AND TICCIT

Today's CAI users are fortunate to have several CAI options, of which PLANIT is one.

- PLATO is for the person who can have everything and has the money to pay for it.
- TICCIT is for the person who has nothing and wants a lot but has little money to pay for it.
- PLANIT is for the person who has equipment and needs to get along on what he has because he has virtually no extra money for CAI.

For some time PLANIT was considered to be an interim system, to be used until PLATO and TICCIT were ready. Support required for PLANIT has been a fraction of that for the other two. No hardware development efforts were involved since PLANIT is completely software, at least up until the time of installation. Thus, PLANIT was less expensive to develop more quickly delivered, making it a likely candidate for interim needs. However, it is becoming increasingly apparent that PLANIT's portability is providing an option not yet available in another CAI system. Because PLANIT can be mounted on existing equipment with little or no extra hardware investment, PLANIT lessons on all such installations are fully compatible and can be exchanged freely. Experience at operating versions of PLANIT which have been installed on widely differing hardware show no discernable differences to the user. It is a striking experience to sit at the keyboard of a strange system where PLANIT is mounted and immediately be completely familiar with the entire operation. This transferability has been particularly useful to the military because of their diversity of hardware. The ability to produce a fully compatible system on existing hardware at nominal costs suggests something more than an interim role for PLANIT. It may well continue to be a viable option for some time to come.

When discussing PLANIT's future, the question is inevitably asked, "Can PLANIT handle graphics?" The answer is "yes" but the implementation of a graphics capability is probably 95 percent installation hardware and software and five percent PLANIT additions. Holes have been intentionally left in PLANIT's command structure to allow for these kinds of additions. In one experiment with graphics, a Rand tablet was used for a PLANIT terminal with the display projected onto the under side, giving the impression of inking a surface with an electronic pen.[1] It has also been observed that the PLATO plasma terminals would make nice PLANIT terminals. These kinds of questions are answered at installation time.

The most significant recent development in CAI is the availability of options, not just the name of the language but the kind of system. Formerly, the CAI author had only one option, to invent a unique system. Now there are several more, including those described in this chapter. If this progress is to be sustained, then interested parties should feel obliged to see what is available. Articles on CAI appearing within only the past six months in respected national periodicals show that this has not yet occurred. One lists PLANIT and TUTOR (PLATO's author language) among others as "large and complicated and troublesome to learn" and then proceeds to describe a language of dubious improvement bound to specific hardware.[2] Another describes yet a different language[3] in which the technique of prompting the author for lesson inputs is ostensibly discovered, not mentioning that PLANIT has been doing this for eight years in addition to several others that can also be named. It was especially interesting to note that after discussing the remarkable gains in efficiency which were attributed to prompting, the authors of the article then proceeded to describe the soon-to-be-released version II which will allow batch input.

Legitimate options in CAI, not contrived ones, are needed. PLANIT is one of these legitimate options.

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# Chapter 19

## Are Faculty Members Educable?

### What Do Faculty Members Need to Know About Computers?

**by Ronald Code**

The problem of how best to introduce the faculty to the computer is interwoven with the question of what should be introduced or taught. If one only knew how the computer should best be used in Biology 101, one would have a better idea of how to train biology teachers. It can be used for statistical computations and hypothesis testing, for control of laboratory experiments, for simulation of hard to duplicate events, for CAI, and for a dozen other facets of this single subject. Even if everyone agreed on the best use of computers in a particular subject, the delivery provides sufficient diversity to keep any training project from getting off the ground if it were to address every possibility. A comprehensive training course must consider minicomputers vs. maxi machines, batch vs. interactive machines, display vs. hardcopy, and the list goes on.

Most colleges are not faced with all of these questions unless they are planning the installation of an entirely new type of system. A machine may handle only batch processing, and the only computer language available might be FORTRAN. The point is that the approach to faculty training in computers *is* related to the tools which are available.

The Northern California Regional Computer Network was fortunate to have the use of advanced computer facilities, to have previous experience operating a regional network, and to have adequate funding to conduct an independent program. Some of the key aspects of this project relate to faculty training projects in general.

Underwritten by the National Science Foundation and directed by Stanford University, the networking was comprised of 18 colleges within a 100-mile radius of the San Franciscan mid-peninsula. The project lasted approximately two and one-half years and was completed in December of 1973.

Although there are in excess of twenty other NSF regional networks and another dozen or so which sprang from state direction or private leadership, the NCRCN network was unusual in several ways. First of all, its emphasis was on faculty training and on innovative curriculum development rather than resource sharing. The concept and operation of a star network (one large institution supporting many satellite locations) had been well tested by 1971 when NCRCN began. Furthermore, most of the 18 regional schools were already well into the computer age. In the first Conference on Computers in the Undergraduate Curricula (University of Iowa, 1970), a paper was presented by a physics teacher from one of the network's smallest and most distant colleges, Pacific Union. This is the sort of plum which network managers wish to claim as their accomplishment after the project is completed, not before! In comparison to other regional networks, NCRCN colleges were unusually sophisticated in their computer knowledge. Faculty from most had been teaching programming courses and using the computer in engineering calculations for years. Thus, this network began from a point where many others finished.

Whenever possible, the project attempted to use methods and materials which could be transferred to the smaller (in comparison to Stanford's IBM 360/67) machines which were typical: IBM 360/30; IBM 1130; Burrough's 3500; and so on.

The plan for the network centered around two annual month-long summer sessions which were attended by four faculty representatives from each of the 18 colleges. Participants also were given 25% release time during the school year to pursue computer projects. One initial concern was the lack of distinguished professors to act as leaders for the many disciplines represented in the network. The project was to be lead by computer center staff members who had limited teaching experience and only vague ideas about how one might actually use the computer in any particular subject. These concerns were reinforced when I found that all similar projects were organized around such faculty leaders. However, the approach, more from necessity than by design, worked very well. In fact, NCRCN organizational structure may have been responsible for the generally high enthusiasm which the regional schools showed for the project.

## NCRCN ORGANIZATION

The 72 faculty participants were divided into four groups: physical science; social science; business; and arts and humanities. The staff member who was chosen to lead one of these groups became as knowledgeable as possible about computer techniques which his or her group would use, and, in general, directed all group activities over the entire network lifespan. The four group leaders worked half time on the network during the school year and full time for the summer session and the month prior. Each participant knew his group leader well and felt free to visit or call about programming problems, computer questions, and so on. Since the group leaders visited the schools, planned regional meetings, selected guest speakers, searched program sources, they actually did most of the work in the project. This pattern contrasts with some networks where the faculty leader frequently was reluctant to begin the project in the first place and, just as frequently, ended up swearing not to become involved again. If the faculty member were a true computer nut, on the other hand, the participants might resent a smarter than thou attitude and transferred any latent hostilities to the network. In other networks faculty leaders often were not interested in doing some of the grungy work which really made the project tick like the telephoning, memo writing, hand holding, and program consulting. This is not to say that distinguished experts are unnecessary to a project of this type; they were essential for guidance and essential as guest lecturers. However they did not need to be the organizational nucleus of a faculty training project, especially one over a long time span.

The first summer session contained many dog and pony shows interspersed with programming classes. An effort was made to avoid the now classic pitfall of such summer programs, to offer a condensed Master's in Computer Science specializing in computer languages. While a choice of several was offered, staff attempted to limit each participant to one computer language. For all those dealing with mathematics, BASIC was taught. Others learned SPSS, FORTRAN or SNOBOL. A few teachers had a hard time learning BASIC and a couple of slow learner sessions were set up to see that no one would be lost.

If the first had been the only summer session for NCRCN participants, most of our work would have done nothing more than provide a month of diversion for 72 teachers. It was during the school year that teachers began to think about how the computer would be related to their classes. They realized that not enough consideration had been given to this thought in the summer as they were watching demonstrations and passively enjoying the program. It is very unfortunate that many other faculty training projects have had only the single major educational phase since the payoff cannot be obtained until the second, third or fourth years. The second summer session which placed emphasis on individual projects and team projects was very successful. Any faculty training project which involves considerable investment ought to be spread out over at least a three-year period, preferably five years.

## NCRCN LESSONS

Because the network colleges could send anyone they pleased to join the project, only one teacher participated in Spanish, one in pharmacology, one in operations research and other scattered disciplines. Although these teachers were accommodated by very broad groupings, they could not develop joint projects and share notes the way the sociology teachers could. Also, the group leaders were stretched thin trying to cover so many disciplines. New faculty participants to the project (incidentally, there was only a 20% turnover in two years) were screened to make sure that their plans were feasible and reasonable. If this had been done from the start, some duds could have been eliminated. A small faculty training project should concentrate on, at most, a few different subject areas to avoid over extension and, thereby, guarantee that sufficient peer interaction occurs.

One issue which is invariably raised with regard to faculty training is incentives. The NCRCN project provided a variety of such incentives which included full salary during the summer month and release time during the school year. If anything, too many incentives will attract teachers for this reason alone and allow them to perform in a passive, and only minimally satisfactory way. A better approach would have been to provide a stipend to cover the costs of transportation, meals, and lodging only. Those who really wanted to use the computer would not have needed further rewards, and the money could have been spent to provide a longer project lifespan. Six faculty members attended the second summer session as associate participants, and they received no pay. No difference was apparent between their performance and the others'; if anything it may have been better.

Although BASIC was the primary computing language for the first summer, staff would now choose a different one. BASIC is a relatively simple computer language which is designed around the world of mathematical notation and application. It was difficult to interest the English teacher in anything which could be done easily in BASIC. In an effort to address a growing interest in CAI, NCRCN implmented a simple CAI author language known as PILOT or RYLON. In future projects where the audience is very heterogeneous, one might use this language for their first introduction to computers since it is simpler than BASIC, and it can be used to produce programs which every educator understands and appreciates, programs that teach. This language is available for several time-sharing computers since it can be written in BASIC. There was an article about PILOT by Sylvan Rubin of SRI in the November '73 issue of *Computer Decisions*.

One of the expected results of the project was a chain reaction of computer knowledge, ignited by freshly energized participants. Most of the colleges did experience this secondary effect. At least three community colleges held formal training classes for their faculty. One college arranged graduate credit for its program, an incentive to most junior college teachers in California, and received state aid money to boot. At each of the network schools at least one of the four participants became a leader in determining his campus's computing future. This was a significant development in those institutions where the data processing or computer science department had called all of the shots previously. Some quantitive measure of the project's success can be gathered from the fact that five network schools have added a total of 90 terminals in the last 12 months.

## CONCLUSION

Any faculty training project should be geared to both the participants and to the tools available. Reasonable goals should be set, and evaluation and review used to keep things on track. The time span for results should be set in terms of years not months. The scope of the project should not be so great that it becomes watered down. It is better to concentrate on a few disciplines and choose or select participants carefully. Remember that the typical teacher is interested first and foremost in his or her own work and teaching. S/he should not be expected to learn about computers because it's good for everyone. Given reasonable applications suited to their teaching area, provided with tools which are not too difficult to use, many teachers will astound the training staff with their energy and enthusiasm for developing and using computer materials.

# Designing a Better Mousetrap

**by Joseph R. Denk**

By promoting instructional usage of the computer, the computer center is building a better mousetrap. Knowingly or unknowingly, the center attempts to trap the faculty and students into usage (for whose survival?) and gets itself caught in a trap: setting up educational training without either the substantive foundation for selecting approaches or the precise formulation of educational objectives to communicate the selected approaches. As a result, the faculty training ventures result in what is measured as low adoption percentages and enough dissatisfaction with selected approaches to increase the doubts on the relevancy of the approaches.

After 57 workshops training over 3,000 faculty with computer-based instruction in North Carolina, some data is available on how to build the better mousetrap. This paper uses the experiences and the results to suggest the formulation of faculty training workshops in light of the vested interests of the computer center. The gap between the substantive foundation of computer-based instruction and the skills of the center personnel are proposed as a major cause of doubts of effectiveness. Another major concern involves the pedagogical inadequacy of computer center people both in training faculty and in pushing curriculum usage. Suggestions proposed for workshop activity, therefore, lie in bulding links between the computer center and the classroom, and not between the computer center and the individual user. Computer centers already know how to train people to use their system.

Workshops on computer-based instruction required a new set of skills due to emerging substantive concepts and heretofore unavailable pedagogical approaches. Without attacking the acquisition of these new skills as objectives, a workshop is doomed to even lower adoption rates than those which any educational techniques would produce in expectation of teacher change. Add the complication of the new media of computing and even more effort is necessary.

## WHERE DOES ONE START? OBJECTIVES!

As obvious as it seems to require objectives before designing a workshop, this most critical area is not at all obvious to computer center personnel. Usually, a workshop is based around either of two extremes: available package(s); or the desire to teach programming or system skills. Neither of these extremes are necessarily objectives for faculty, despite their acceptance as needs by the computer center. Mere experience with usage of some package(s) rarely fits the instructional needs of the faculty and rarely does the faculty member have the interest and/or leisure time to learn all the center would like him or her to know. Finding the right mix of objectives for both the center and the faculty is a complicated affair that rarely involves only center personnel.

Short courses on programming languages and statistical packages that are the common to every large computer center are not usually targeted toward classroom instruction. These courses draw a few computer buffs and can be well structured by the center staff. Since the objectives of such courses are to provide familiarity with languages or to use a package, no real problems exist.

The rarity of computer center workshops on curricular approaches is a witness to the problems involved. If a package of programs for teaching chemistry becomes available on the system, who in the center can handle the chemistry? And if someone can handle the chemistry, who can handle the pedagogy? A simple exposure of such a package promises to produce rare adoption without depth. In order to establish objectives that promote adoption, a teaching chemist with experience in the packages should assist in setting up objectives and in the design of the workshop. Leaving it all to the computer center limits the objectives to simple adoption which is doom for the vast majority of computer-based curriculum approaches.

In the North Carolina experience, most of the beginning curricular workshops were designed for simple adoption by the center staff. As the number of experienced users grew slowly, these users were involved in subsequent workshop design. This evolution culminated in the 1973 Institute for Undergraduate Curricular Reform (1973 IUCR) in which all nine workshop programs were designed entirely by teachers with the computer center personnel only present to assist in implementation (seven design teams involved 42 faculty).[1]

The set of objectives reached in the 1973 IUCR clearly indicate the differences between workshop criteria design by computer center personnel and by faculty. Over and above simple adoption of packages objectives included:

- Managerial skills required for classroom usage;
- Minimal programming skills for potential modification of packages to needs;
- Pedagogical technicques;
- Concepts of course design;
- Evaluation criterion;
- Core concepts in quantitative techniques;
- Fundamentals of statistics and methodology;
- Skills for creating one's own data sets;
- Skills for subsetting existing data sets; and
- Fundamentals of modeling theory.

Such a mix of objectives is normally beyond the resources of computer center personnel and usually beyond the capacity of one individual. However, such a set of objectives produced 40% adoption by the 248 personnel involved in the 1973 IUCR as compared to the 15% adoption rate of earlier workshops. No single approach can be expected to be totally acceptable to any teacher who needs the flexibility to adopt according to specific needs.

## MATERIALS: THE FOUNDATION OF WORKSHOPS

Objectives cannot be set up for workshops without simultaneous selection of materials. It is essential to understand the nature of computer-based curriculum materials (CBCM) in order to set up attainable objectives. In order to promote adoption of approaches rather than to wait in vain for wide acceptance of the all-too-few materials, it is especially urgent to understand the nature of the few available CBCM.

Over 500 "curricular" entities were workshopped in North Carolina. A set of categories in Figure 1 can be used to clarify the nature of these materials.

Even the more integrated materials like COURSEWARE WITH PROGRAMMING and INTEGRATED COURSES require in-depth training in pedagogy and implementation due to the foreign nature of the teaching strategy. In these categories, greater flexibility in the teacher is a more serious requirement than in modules as a result of the overall impact.

PACKAGES – INTEGRATED and DATA ANALYSIS PACKAGES require an entirely new set of substantive and methodological skills beyond traditional courseware. In workshops involving empirical techniques as replacements for traditional inductive approaches, the reorientation of the instructor to these technicques is far more critical than

**Figure 1. Categories of CBCM – N. C. Experience**

| Category | Description | Example(s) |
|---|---|---|
| MODULES | An isolated curriculum module treating one or more topics without specific textbook correlation. | KNEXP – A simulation for teaching experimental Design in chemical kinetics. (2) |
| PACKAGE – MODULAR | A compilation of modules covering several topics approaching one or more courses without specific textbook correlation. | WHYBARK – Case studies in Operations Management using simulations and models. (3)<br>JOHNSON – 24 models for a variety of topics in chemistry. (4) |
| PACKAGE – INTEGRATED | An integrated set of modules under a centralized function without any textbook reference. | SPSS – Statistical Package for the Social Sciences. |
| COURSEWARE WITH PROGRAMMING | Topical treatment along the lines of specific courses which involves programming but not necessarily specific textbooks. | COEXIST – Introductory Physics topics involving computer programming for solutions to problems. (5) |
| BUSINESS GAMES AND SIMULATIONS | Textbook-like materials involving simulations. | TEX6 – The Executive Game. (6)<br>INS – Inter-Nation Simulation. (7) |
| EXAM GENERATORS | Adjunct materials to specific courseware involving examinations. | CGRE – Computer Generated Repeatable Examination System. (8) |
| INTEGRATED COURSES | Materials for at least a major segment of classical courses with textbook correlation. | PILLSBURY – An integrated course in introductory accounting. (9) |
| DATA ANALYSIS PACKAGES | "Kits" for doing data analysis in the classroom without textbook correlation. | BOYNTON – Nine teaching units involving SPSS and social science data. (10) |
| CAI | Classical Computer-Assisted Instruction | PLATO (ILLINOIS) – Many disciplines.<br>LAGOWSKI (TEXAS) – Chemistry. |

The nine categories of materials in Figure 1 are not mutually exclusive or exhaustive but are convenience descriptions for workshop design. As would be expected, the majority of available CBCM fall into the MODULAR, PACKAGE–MODULAR, and BUSINESS GAME – SIMULATION categories. Since this majority has little inherent relation to courseware such as textbooks, pedagogical skills and courseware design are more important as workshop objectives than in training sessions with materials closely related to classical courseware. Further, the probability of adopting these approaches is enhanced by providing the skills necessary to modify modules to specific needs.

the mere acquisition of computer-accessing skills. Canned data represents quite specific experimental design and does not represent, as is often believed, an unlimited number of areas of study for undergraduates. Even after training in skills for accessing canned data, a few data sets will not be enough for the instructor. Instead, he also needs to be able to put data from his own design into the classroom.

Classical CAI requires the least technical training but the most depth in evaluation and pedagogical skills. Cost and support considerations are also important.

Workshop objectives proposed as minimal for the categories are:

*MODULES*

- Accessing skills
- Managerial skills
- Substantive meaning of model
- Flexibility for modification
- Pedagogical techniques

*PACKAGE – MODULAR*

Same as MODULES but extended for all modules.

*PACKAGE – INTEGRATED*

- Skills for flexible usage
- Limitations
- Methodology
- Specific practice

*COURSEWARE WITH PROGRAMMING*

- Pedagogical skills
- Programming
- Substantive training

*BUSINESS GAMES AND SIMULATIONS*

- Accessing skills with flexibility
- Managerial skills
- Evaluation criterion
- Implementation techniques
- Limitations of model
- Substantive skills

*EXAM GENERATORS*

- Accessing skills with flexibility
- Managerial skills
- Evaluation criteria
- Implementation techniques

*INTEGRATED COURSES*

- Accessing skills with flexibility
- Substantive skills
- Pedagogical implementation
- Evaluation criteria

*DATA ANALYSIS PACKAGES*

- Substantive skills
- Methodological skills
- Implementation techniques
- Accessing skills with flexibility
- Computer skills for data base management
- Evaluation criterion
- Pedagogical skills

*CAI*

- Pedagogical implementation
- Evaluation skills
- Accessing skills

The rarity of CBCM workshops incorporating these objectives is understandable as should be the low adoption rates resulting. But both the materials and corresponding objectives do not complete the special workshop requirements for introducing CBCM.

## CUSTOMIZING THE WORKSHOP TO THE OBJECTIVES

Customizing the workshops to include the software support and the attainment of objectives is necessary for each category of materials. It is tempting to try to construct a matrix relating workshop design parameters to objectives and materials but the temptation is easily cast aside when it is realized that any workshop may have several categories of materials. Enough specificity can be obtained by relating design parameters to workshop objectives.

The following design parameters are proposed as minimum consideration for CBCM workshops.

*TIME LENGTH*

- Contact hours with instructors
- Contact hours with machines
- Discussion periods
- Courseware design periods

*AVAILABILITY OF INSTRUCTORS*

- Experienced faculty in implementation
- Substantive content
- Evaluation
- Experienced bridge personnel[11]

*AVAILABILITY OF MACHINE OR TERMINALS*

- Computing power sufficient to meet the objectives

*TARGET AUDIENCE*

- Experience with computer
- Experience with relevant courseware
- Experience with methodology

*RELIABILITY OF SOFTWARE*
*COSTS*
- Costs for workshops
- Costs for instructional usage

*COMPUTER ENVIRONMENT*
- Workshop
- Home of participants

While the TIME LENGTH of workshops dealing with modular materials can be as short as 1-2 days, the attainment of substantive, and pedagogical skills forces this time frame up to 1-2 weeks. As the materials become more integrated, restructuring of courses, obtaining flexibility, and learning enough methodological and quantitative skills also drive the time requirements up to the 1-2 week length. Very few adoptions will result from 1-2 day programs and, unless a longer commitment is made, these adoptions will not prove satisfactory to the computer center. Modification of CBCM to a teacher's interest is not a possible outcome of short programs.

Experience both in classroom usage and evaluation in faculty should be present in the AVAILABILITY OF INSTRUCTORS. It is sufficient for exposure to have bridge-role personnel to get over accessing objectives but the remaining goals will be frustrated by this experience. No better workshop can be run than one where the classroom is closely simulated in the workshop itself by experienced instructors. The probability for adoption is increased where evaluation data is also available. Design without experienced faculty can be done if the above-mentioned objectives are ignored.

AVAILABILITY OF MACHINES OR TERMINALS is a *sine-qua-non* for any kind of adoption since CBCM demand hands-on activity. There is no substitute for laboratory work in this field.

If the TARGET AUDIENCE is obtained after the workshop is announced (the usual case) then this parameter can be ignored. However, the dangers of boring or losing the audience become more significantly under the usual conditions. So much emphasis must be placed on ancillary skills (keypunching, data structure, fundamentals of programming) that to ignore these for beginners seriously hinders adoption of techniques.

The RELIABILITY OF SOFTWARE must be guaranteed. Doubts on this reliability will inhibit all potential activity. Further, the spectrum of techniques should be broad enough to support modification and provide a variety of interest in order to draw a large enough population.

Information on COSTS must be available on each student if possible. This parameter can often be placed first on the list. The COMPUTER ENVIRONMENT of the workshop should be tuned to that of the participants. Interactive approaches cannot help those without facilities for these services. Large software packages are too difficult to reduce to smaller machines.

## A CAVEAT OR TWO

It is unreasonable to expect to obtain all of the objectives all of the time. The workshop learning experience will only bring more problems to the computer center. Skills considered to be acquired will always be insufficient during implementation; materials will always show up more bugs; modification will continue forever. Some continuity in consultation from both faculty instructors and center personnel has to be provided. Getting into this support is almost a Pandora's Box and is surely a mousetrap. North Carolina has 12 personnel at the central network computer just supporting this activity without any systems responsibility. The network holds together via faculty interchange. The only bright financial spot are the unfunded voluntary roles of faculty in this exchange. As a result of the 1973 IUCR, this exchange is even stronger. It is hoped that this condition will hold long enough until the promised day when all campuses will have the foundations in their faculty.

The expected flood of integrated courses or packages has not occurred, and the majority of materials are modular. Since modules do not have the impact to please all parties, the current state-of-the art falls below expectations. Disappointment in this level should be tempered, however, with some satisfaction that the computer is where it belongs – an adjunct tool. It should modify chemistry and sociology but not displace basic pedagogy. Further since the high costs would result from lots of integrated courses, the doubts should remain.

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# Are Faculty Members Educable?

by Gary A. Wicklund

This chapter will describe efforts made at the University of Iowa to inform faculty about possible use of computers in the functional areas of business and to provide training for faculty in computer skills.

## THE ACADEMIC NEEDS

As a part of the academic program in the College of Business Administration, the computer is an important tool. Therefore, use of the computer is integrated into course content in the areas of accounting, finance, marketing, economics, management science, and statistics. When accomplished, this integration has a two-fold result: business students not only become involved with programming and actual experience on the system; they also become informed about appropriate uses of the computer within their functional areas.

Since most graduates of business administration take positions in the functional areas, they are often not directly involved with computers. However, their exposure to computer capabilities during college training allows them the potential of recognizing possible applications of the computer within their chosen field. Comments, commending the value of computer training, from recent graduates of business administration have led to some increased faculty interest in the expansion of computer skills and usage into more courses. Although faculty with computer skills have taken the initiative to make changes in their courses, this has not been enough. Many faculty members who do not have computer skills have not been involved in using the computer in their courses. As a result, there is a need for making appropriate computer information and training available to all faculty members.

## THE RESEARCH NEEDS

Since research in the business area involves optimization models, statistical analysis and techniques, simulation and so on, faculty members also need to use the computer as a tool in research. In order to use the computer for research the faculty members must be able to either do the programming themselves or communicate with the computer center staff. They need enough information about computers to effectively use the computer as a research tool.

Because the computer has become an important part of what is happening in the business areas, the faculty are aware of some of the capabilities of the computer. It is an individual question whether a faculty member becomes a user of the computer in the classroom or in research.

## IOWA PROGRAMS IN BUSINESS ADMINISTRATION

Iowa business administrative faculty during the past few years have reviewed the academic programs of the college in comparison to programs of other major business schools. This review suggests that existing programs are academically sound, and, relative to other leading business schools, contemporary. Consequently, future changes will probably be more in the nature of methodological modification using computers in contrast to pronounced substantive change in direction. Although Iowa programs provide flexibility in student course scheduling, the academic program for each undergraduate requires work in each of five areas: 1) Background in the concepts, processes, and institutions in marketing and distribution, production, and financing functions of business enterprises; 2) Background of the economic and legal environment of business enterprise along with consideration of the social and political influences on systems; 3) A basic understanding of the concepts and methods of accounting, quantitative methods, and information systems; 4) A study of organizational theory, interpersonal relationships, control and motivation systems, and communications; and 5) A study of administrative processes under conditions of uncertainty including integrating analysis and policy determination and the overall management level.

Academic programs are administered by the departments of Accounting, Business Administration, and Economics, and in conjunction with the College of Education, the Department of Business Education.

During 1972-73 there were 877 upperdivision undergraduates and 848 pre-business freshman and sophomores. In addition, graduate courses are offered for the MBA, MA, and Ph.D degrees in Business Administration and academic programs are offered in the same areas for the undergraduate students.

## COMPUTER FACILITIES

The College of Business Administration at The University of Iowa has access to two computer systems. One is an HP2000F computer with sixteen terminals located in the Computational Laboratory within the college. This system was acquired in the summer of 1973. The other system is an IBM 360/65 system located at the University Computer Center with both batch and interactive programming capabilities.

## FACULTY TRAINING

At The University of Iowa, the College of Business Administration has instituted a number of changes in its academic programs implementing the computer as a tool in instruction and research. Both the faculty and administration of this college are ready to support further computer developments that have promise for making substantial contributions to the education of students who seek development in the field of business administration. Several methods of involving faculty in using the computer have resulted in changes in the academic programs.

The primary goal in the College of Business Administration was to increase use of the computer in instruction and research. One initial method of satisfying this goal was to increase the accessibility of the computer to faculty members. Computer identification numbers were issued to each faculty member. The computational laboratory also provided assistance in getting the faculty member on the computer by supplying documentation describing and illustrating the steps of logging in. In addition, two portable terminals were made available to faculty members to use in the privacy of their office or residence. This current procedure had been suggested by the success of locating a terminal for interactive use of the IBM 360/65 in a small office reserved for faculty. It was found that some faculty desired to do their learning in a private environment. Also, faculty members who were teaching courses found it difficult to be productive on the computer when they were trying to work in the same environment with students.

In the College of Business Administration sixteen terminals were installed with the intent of being sufficient for the number of users – both faculty and students. In order to get usage of a computer system by the new computer user, terminals must be available with little or no waiting time. Difficulty in obtaining a terminal will discourage a faculty member (and also a student) from using the system.

Once accessibility of the computer is insured, appropriate software must be provided which will meet the needs of the faculty members. Does s/he want to learn a programming language? Does s/he want to run a library program? Short courses and computer tutorials are helpful in providing assistance with software.

At the University of Iowa the business school has used several training techniques for informing the faculty about both languages and available software. Tutorials are available on the computer system for teaching interactive BASIC and PL-1 to which both faculty and students have been receptive. Also video tapes which assist in teaching BASIC, PL-1, and other languages are available to computer users at the University Computer Center. For some faculty this has been an effective method of satisfying the need to learn a computer language.

The University Computer Center has offered non-credit short courses which were attended by business administration faculty members who had some computer skills. These faculty members then offered noon-time seminars for their colleagues in which topics and examples to be of interest in the functional areas of business were presented. Topics consisted of both programming languages and software programming packages. By providing information about software programming packages in the functional areas, the amount of computer programming knowledge needed by the user was minimized. Once the user has successfully identified himself or herself to the system, s/he is ready to use any of the software programs found in the system library.

After attempting to develop software for the interactive and batch processing systems on the IBM 360/65 for several years, it was found that obtaining software programs from other business schools which were directly applicable to the new system caused an almost instant increase in computer usage in the classroom. Faculty were willing to try some of the statistical programs and readily make use of them in their functional areas and in applications in accounting, finance, and management science.

Good software which is well documented is essential for computer usage. Faculty members who have little interest in computing can make use of library programs almost immediately. However, evaluation of software is recommended when a computer user acquires someone's program. Software packages can be obtained from other schools of business or from computer manufacturers. Also, newsletters dealing with computer topics can provide a source of information since they contain brief descriptions about software which is available. For those faculty members who began to write their own programs for use in instruction in the functional areas, it was essential to provide guidelines on documentation and program development. However, these guidelines resulted in the development of programs which were documented and transferable.

Another method of introducing faculty to computer use is to offer assistance to the faculty member from research assistants. In the College of Business Administration several graduate research assistants and hourly employees are responsible in the laboratory who offer assistance in programming. Research assistants provide the type of resources needed to make computing available to the occasional user of the computer system. These individuals are familiar with the questions raised by the different users of the Computer Laboratory.

Faculty members in the College of Business Administration have shown interest in using the computer as a tool for their instructional and research needs. The efforts in training faculty, providing software programming packages, and programming assistance have resulted in an increased use of the computer in instruction.

## Training Teacher for Change

**by Jo Ann Baughman**

The report of the Anastasio and Morgan study of 1972[1] indicated that adequate facilities and quality course materials are available and that subject matter can be taught more rapidly, meaningfully and thoroughly with the computers' aid. The proper use of computer in instruction can make education more productive and effective and allow for greater individualization and provide for greater equality of educational opportunities. In addition, the authors claimed that computers could make their greatest contribution to the instructional process by enabling students to interact with systems of realistic complexity especially in the physical, social and behavioral sciences, business, engineering and medicine.

If computer related curriculum materials can be shown to meet concrete needs, teachers will more readily adopt them. To this end, demonstrations must be combined with careful, honest and critical examples of programs and text that convincingly indicate the effectiveness of the applications in the classroom and the effectiveness to the student. This educational documentation should also entail some analysis of cost-effectiveness, specification of goals and measurement of instructional effectiveness.

Although the effective implementation of the teaching/learning process is a primary concern of all educational institutions, in post-secondary education the goals of the learner become more diverse. This diversity in the learner's demand has caused many instructors to question their teaching processes and to make varied attempts to design innovative instructional changes. College faculty today, however, do not have the knowledge for instructional design nor the knowledge of the education technology needed to make major changes in their instructional technique. In fact, many instructors are unable to use the instructional services currently available on their own campuses simply because they do not know where to start in the process of instructional development. In some cases instructors who enthusiastically try out new methods, sometimes at great expense, become discouraged about instructional innovations because they have chosen the wrong approach or do not understand other fundamental aspects of instructional design.

If instructors are to design, develop, produce or implement independent learning programs, incorporating current educational technology, they must be offered the opportunity to receive instruction in the techniques for instructional change.

The computer is one of the current tools of educational technology available to faculty which can be an exciting teaching device. It is, however, no panacea. Although it alone will not teach the students nor teach the faculty, it can amplify the instructor's own teaching capabilities. Thus, its effectiveness varies directly with the capability of the teacher and his or her willingness and ability to undertake those critical components of good teaching; objective setting; testing; diagnosis; and developing prescriptions for individualized teaching.

## EDUCATING FACULTY

Realizing that many faculty are willing and able to make thi investment in teaching, many computer centers throughout the nation offer workshops, for the purpose of helping the teachers make use of this powerful and useful component in their teaching programs. However, these workshops have traditionally had six weaknesses:

- Insufficient institutional commitment to participants;
- Inadequate motivation of participants;
- Lack of goals and objectives for the workshop;
- Insufficient planning for the workshop;
- Lack of resources, computer curriculum materials and discipline-oriented workshop leaders; and
- Insufficient follow-up activities to assure sustained effectiveness.

In short, teaching programming to faculty, (a favorite pastime of many computer centers) is not sufficient for effective use of the computer in the classroom. CONDUIT workshop activities have indicated that extensive pedagogical documentation and instruction are necessary for effectively adopting a computer curriculum module into a teacher's courses.

Since a workshop is an instructional entity, it too is a system and some strategies need to be observed for effective implementation. "The key criterion by which the effectiveness or adequacy of the performance of a system can be evaluated is how closely the output of the system satisfies the purpose for which it exists."[2] If a workshop is to address the instructors' needs of awareness, availability, examples of use, and usage; then it can lead to satisfactory adoption of educational technology into the classroom. However, a systems approach needs to be adopted for the design and implementation of the workshop. Figure 1 suggests a decision strategy for selection of materials to be workshopped.

## NEEDS ASSESSMENT

A quick and qualitative profile of the average faculty at the average university, indicates that one third are interested but lack sufficient substantive background to apply the theory inherent in many uses of the computer in their field. Another third are interested but lack time and incentive, and the last one-third could care less. Data collected from the last two years of the CONDUIT project has indicated that those faculty who were interested enough to apply to workshops had a computer literacy rate of 15% to 38% depending upon the discipline.

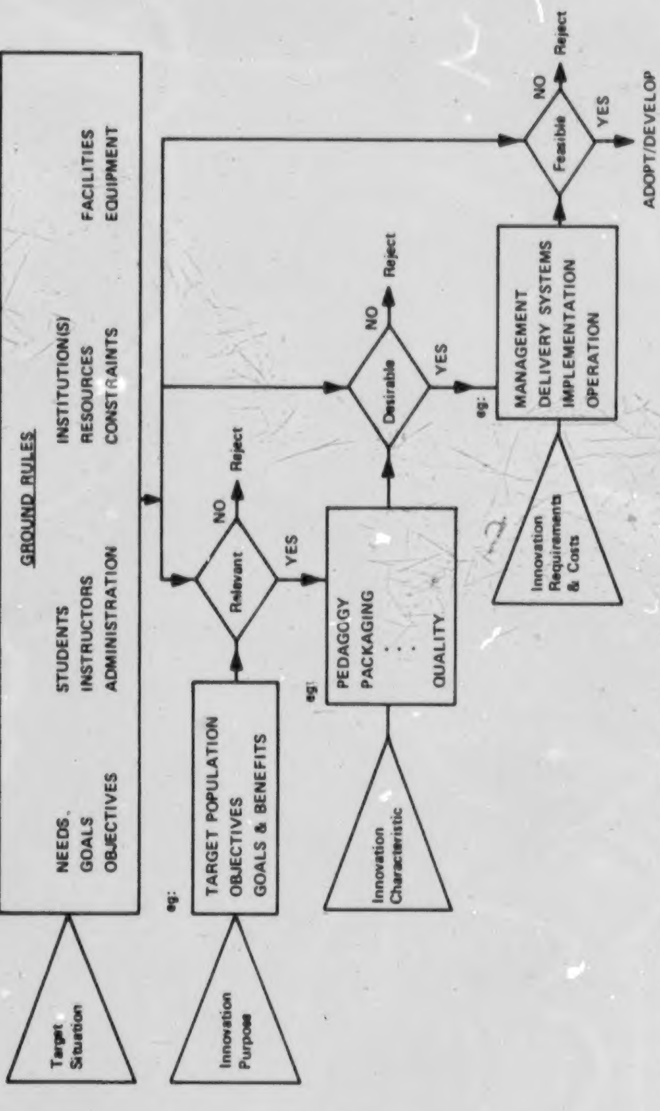
Workshops need to be aimed at meeting the needs of the two-thirds who are interested and willing to devote the time for effective implementation of the computer as a teaching/learning technique into college classrooms. The following list illustrates some of the needs that must be met if the college faculty are to become familiar with the techniques for implementing and incorporating the computer into the classroom framework.

*AVAILABILITY*
- Bibliographic only
- Catalog reference, CONDUIT school/elsewhere
- On-line, immediately available
- Program library, CONDUIT school/elsewhere

*USABILITY*
- Documentation, Technical/Educational
- Ease of Implementation
- Staff support (Human interface)
- Degree of user control
- Convenience of use
- Reliability
- Credibility
- Flexibility
- Relevance

*VIABILITY*
- Longevity

Figure 1. Decision Strategy for Evaluating Computer Oriented Curricular Materials for Workshops*


Target Situation
GROUND RULES
NEEDS, GOALS, OBJECTIVES
STUDENTS
INSTRUCTORS
ADMINISTRATION
INSTITUTION(S)
RESOURCES
CONSTRAINTS
FACILITIES
EQUIPMENT
Innovation Purpose
eg:
TARGET POPULATION
OBJECTIVES
GOALS & BENEFITS
Relevant
NO
Reject
YES
Innovation Characteristic
eg:
PEDAGOGY
PACKAGING
. . .
QUALITY
Desirable
NO
Reject
YES
Innovation Requirements & Costs
eg:
MANAGEMENT
DELIVERY SYSTEMS
IMPLEMENTATION
OPERATION
Feasible
NO
Reject
YES
ADOPT/DEVELOP

*This strategy was developed by HumRRO, McLean, Va.

- Ease of modification
- Obsolescence factor
- Success of usage

*MANAGEABILITY*

- Cost in dollars
- Cost in teacher-time
- Cost in technical support-time

The instructor needs to become aware that these techniques must be evaluated and validated just as books or any other instructional tool. In order to complete such an evaluation s/he needs to have a general overview of the facilities available in education and the related systems before endeavoring to use them within a course. Faculty and staff members also need the opportunity to learn more about the capability inherent in the educational use of the computer. Finally, if computer curriculum materials are to be effectively adopted in a teacher's course, rather extensive pedagogical documentation for the in-class use of these materials must be provided.

The major constraint imposed upon the workshop system is the recognition that faculty who are hard pressed to keep abreast of developments in their own fields, can seldom find the time and money to investigate in new instructional tools and techniques. Workshops need to meet the user's needs of awareness, adoption for use and satisfaction.

## GOALS AND OBJECTIVES

The first workshop objective is to identify good materials and reliable resources. The second is to meet the needs of the identified faculty. The third objective is to determine the learning strategies appropriate to the audience, the materials and the resources available.

Figure 2 gives some indication of the parameters involved, in planning a workshop for instructional computer materials.

## THE WORKSHOP

Oregon State University workshops are set up to provide the faculty with concise instruction, examples of use, and an opportunity to receive actual hands-on use of a computer under the guidance of an expert discipline-oriented instructor, and in accordance with an old Chinese proverb: "I hear and I forget. I see and I remember. I do and I understand."

Workshops may be from one day to two weeks in length. They are characterized by the fact that the participants actively engage in the learning via lecture techniques.

Criteria for determining the success of a workshop can include the

Figure 2. Workshop Parameters

| Type of Material / Activity | CAI | Courseware with Programming | Integrated Course Materials | Simulations | Modules — Packages | Analytical Tools — Canned Programs | Data Base or Systems | Business Games |
|---|---|---|---|---|---|---|---|---|
| *Substantive Skills (discipline or analysis)* | Med. | Low | Low | High | Med. | High | High | High |
| *Educational Methodology Skills (Involved in Use)* | High | Med. | Med. | High | Med.-High | Med. | Med. | High |
| *Computer Skills* | Low | High | Low | Low | Low | Low | Low | Low |
| *Evaluation Criterion* | High | Med. | Low | Med. | Med. | Med. | Med. | Med. |
| *Pedagogical Transfer* | Med. | Med. | High | High | High | Med. | High | High |
| *Managerial Skills* | High | High | High | High | Low | Med. | High | High |
| *Participant/Computer Ratio* | 1/1 | 1/1 | 3/1 | 1/1 | 1/1 | 1/1 | 2/1 | 1/1 |
| *Time Length (In days)* | 2-5 | 5-10 | 5-10 | 2-5 | 2-5 | 2-5 | 1-5 | 1-5 |
| *Hands on Exposure* | | 4/day | 4/day | 2/day | 4/day | 4/day | 4/day | 8 periods or 8 rounds |
| *Pre-Orientation of Participants* | | Low | Med. | Med. | Med. | Med. | Low | Med. |

number of faculty that are: aware of the existing materials; motivated to learn to use the materials; and who adopt the materials for use and continue to use them. This criteria will also measure the success of the support rendered by the curriculum managers to the teacher-users and to the teacher-developers.

## IMPLEMENTATION, EVALUATION AND FOLLOW-UP

Oregon State University Computer Center provides organized follow-up support for the instructional use of the computer which includes: departmental seminars; mini-workshops; self-instruction materials; and one-on-one instruction for faculty on request. In fact, the technical and educational support for the classroom teacher is perhaps the most critical function in the total transportation process. Encompassing all activities necessary to insure the transfer of the educational philosophy and pedagogy of the transported materials, the degree of support required by the instructors ranges from simply sending out the materials for the teacher experienced with the computer, to full technical support for the novice teacher. This technical support includes in-class demonstration, laboratory assistance for the students in the use of the materials, and tailoring of computer programs to the teacher and training faculty for use on existing systems.

Activities involved in this support are:

- Repository Service for Oregon State Instructional Materials;
- Importation of new curriculum materials;
- Implementation of instructional programs;
- Information Resource for faculty;
- Documentation of instructional computer materials;
- Faculty training;
- In-class support of instructors;
- Computer program library maintenance; and
- Development facilitator of computer related curriculum materials.

The CONDUIT/Oregon staff was able to overcome a lack of documentation of and program errors in instructional computer materials through extensive faculty support and faculty training at the regional and local levels. It is quite obvious, however, that computer centers in general are not willing to support a staff of three of four to facilitate and enhance the instructional use of the computers.

It is possible, that the cost of supporting a local staff is less than the cost of seeing that adequate technical program documentation exists, that adequate educational documentation exists, and that exchange procedures are supported by the center. During 1974 CONDUIT will bear a measure of these costs as regional staff attempt to bring the 1972 CONDUIT programs up to standards with respect to technical and educational documentation.

CONDUIT's reliance on Curriculum Coordinators at the regional center to provide the technical verification and the technical support for the faculty-student users has enabled materials to be effectively used by the CONDUIT/Oregon participating faculty despite problems with lack of educational documentation. The teacher, the students, the CONDUIT staff and the computer have all become members of an interactive team.

## THE CURRENT SITUATION

Efforts have been made nationwide to incorporate educational technology into the post secondary curriculum and to prepare self-instructional materials which allow students to move in separate directions at their own pace and according to their own particular needs and interests.

Much of this work is being done in an organized and systematic way by the institutions: Florida State's Division of Instructional Research and Services; the University of Texas' Center for Teaching Effectiveness; Georgetown University's Center for Personalized Instruction; Utah State University's Learning and Resource Program; the University of Michigan's Center for Research on Teaching and Learning and many, many other too numerous to mention.

Under such instructional systems the instructor becomes a source of diagnostic assistance and individual guidance for each student, as opposed to the source of lectures and demonstrations in the traditional classrooms. This also allows much greater curricular flexibility. Unfortunately, but understandably, much of the recent development of independent learning systems has been accomplished in the elementary and secondary schools rather than in post-secondary educational institutions. The Educational Research Information Center for Educational Technology at Stanford University has recently published a survey of individualized instructional programs in elementary and secondary schools which indicates the scope of field development at these levels.

Many high schools and junior colleges have been experimenting with multi-media presentation for several years now. Great exhibits are shown at the Pacific Science Center in Seattle and the Exploratory in San Francisco. Already, on line computer play is available to museum visitors at the Lawrence Hall of Science at Berkley. This trend will continue. At some point students will be asking, in the words of Bob Dylan, "So what else can you show me?". Surely colleges and universities have both the capability and responsibility for making significant progress.

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# Chapter 20

## Institutionalizing Educational Change

### Can Educational Change be Institutionalized?

by Arthur W. Luehrmann

Managing and institutionalizing educational change within the conventional university is intrinsically complicated by departmentalization. The university, like the Holy Roman Empire, has its nominal emperor and pope, but all the action is out in those principates and grand duchies, the academic departments. To use a biological metaphor, the university is a host organism upon which the academic departments live, at best symbiotically, at worst parasitically.

One method of provoking educational change without attacking departmental structures is to produce and market new instructional materials for adoption by existing faculty in the departments. In Chapter 15, Kent Morton describes Dartmouth's Project COMPUTe, which is such an experiment. This NSF-funded project brings authors to Dartmouth, pays their salaries for a couple of months of writing, edits and prepares their manuscripts for publication, negotiates contracts with a publisher, and offers royalty incentives.

Project COMPUTe may be a model for one element of a larger strategy for bringing about educational change for several reasons.

*Change is produced by active teachers with ideas that come directly out of their experience.* The necessity to teach some subject is the mother of their curricular invention, not the necessity to write scholarly papers on educational change.

*Each author is tightly allied to his or her particular academic discipline.* Each is a member of an ordinary academic department. As a result each is an *insider* and can carry out a program of change in a way that *outsiders* cannot. A faculty member may influence others at one university; but, more likely, he or she will influence others in one discipline at dozens or even hundreds of other universities. Communication within disciplines is far more profound than communication within universities.

*The creative staff is a temporary staff.* There are no permanent *innovation* experts, only *discipline* experts who temporarily leave their conventional roles to address a problem of pedagogy. Before they fall prey to thinking of themselves as innovation experts Project COMPUTe sends them home for more contact with the sources of their inspiration.

*Rewards for work in curriculum are not confused with rewards for traditional academic good behavior.* Authors are paid to write, and, if they write well, further royalty benefits accrue. There is no pretense of enhancing professional prestige or tenurability. Simple rules are the basis of good behavior and Project COMPUTe wants authors to behave like authors, not prima donnas.

## NATIONAL MODEL FOR EDUCATIONAL CHANGE

A natural question is, "Is it possible to extend the key features of Project COMPUTe into a full-scale national model for educational change and development?" I believe that the answer is yes.

The Carnegie Commission on Higher Education in a recent report calls for the establishment of several regional centers focusing on uses of technology in higher education. The structure proposed there is the starting point for the full-scale model that I would like to promote. Briefly, each center is to be funded at the level of a small university, such as Dartmouth, for example. It is to have a permanent staff of educators, writers and specialists in video, film, audio, graphical design, and computing. The long-range goal of each center is to develop and distribute applications of technology that increase the quality or reduce the cost of education. Each center would provide educational computer service to its entire region. The centers would be situated in major metropolitan areas so that they would have access to real, live students in the way that the Open University does in Great Britain.

As far as it goes this is a good plan, but it does not go far enough. In particular, the relationship between these essentially research and development centers and the production oriented conventional universities is not clear. At some points in the Carnegie report the centers appear as service organizations for the universities. At others, they seem to be competitors, having their own staff and their own student clientele.

At this point in the analysis Project COMPUTe experience can be of help. Suppose that each center had, in addition to the regional tie suggested by the Carnegie Commission, a very strong discipline tie as well. Each center might be targeted to produce applications in a specialized group of closely related academic fields. Persons representing those disciplines, possibly via the professional societies, or perhaps through editorial boards of the respective journals, would serve as an advisory panel or even a policy review board for the corresponding center. Such a group might advise the center on needs, priorities, and marketability for new educational developments in each discipline. It might also serve as an insider group for the promotion within the disciplines of new developments coming out of the centers.

The actual development process in the centers would be a partnership involving people with technology and media specialization, education theorists, evaluators, economists, and, finally, discipline experts with teaching experience. The latter should usually be the senior partner; the others should serve as resource people. For the reasons stated in describing Project COMPUTe, it is better that the discipline specialists be cast as visiting fellows rather than tenured faculty. In the first place, a permanent staff of innovators is hard to imagine. Second, the discipline tie of the permanent innovator would become thin if not replenished by renewed contact with peers in the discipline. Third, the number of people in direct contact with the center and its work would be vastly larger if the number of visiting fellows was large. Fourth, the return of visitors to their home universities would serve to spread the word and market the products of the center. Fifth, the mere possibility of becoming a fellow at the center would cause many more people to become conscious of and interested in the activities of the center.

Since, in the conventional university at least, the effective consumer of educational change is not the student but the teacher who selects course format and materials, it is crucial that any large educational development centers have powerful ties with the teaching faculties. That means, in vertically partitioned universities, powerful ties with academic disciplines.

It might be argued that educational change cannot happen within universities anyway, so why worry about good relations with them? Why not set up centers that will compete with them in doing the job that they now do?

While an element of competition between the centers and the regular universities is healthy and the presence of "Open University" students would foster that competition, there are two reasons not to cut off the ordinary universities from the start. First there is no need. The proposed model poses little threat and even offers opportunity to the academic disciplines. Second, a frankly competitive organization could probably not attract a staff of sufficient competence to win in a struggle with the conventional universities. It would be attacked by academic specialists as an illegitimate upstart, and that would deter most of the best people from taking a job at the center.

In summary, then, I propose several large regional curriculum development centers, each with very strong discipline ties. These ties would be achieved because the centers would be held accountable to representatives of the disciplines in exchange for legitimacy in their eyes. Apart from the question of ties to academic disciplines, the remainder of the model is essentially that proposed by the Carnegie Commission for developing uses of instructional technology.

## MEANWHILE, BACK AT THE CLOSED UNIVERSITY

It would be poor judgement to do nothing until massive support becomes available for such national centers. One works with what is at hand, and it appears that traditional, closed-wall universities are apt to be at hand for a while. Yet all is not gloomy there.

Dartmouth College has made a recent commitment of resources and personnel toward educational change within a conventional university environment. Operating on the premise that the best source of ideas about education is the regular teaching faculty and the best testbed is found in courses offered in the regular departments, Dartmouth has defined a new office charged with promoting faculty experiments in teaching. Particular emphasis is to be placed on experiments that will lead to qualitative or quantitative increases in productivity through use of technology.

In view of the well-known professional and political problems faced by education-minded faculty members in regular departments, one of the principal functions of the new office is to serve the interests of such people. This will be accomplished in several ways. The first and most important way is organizational. The director of the new office, whose title has not yet been settled, but for present purposes may be called Dean of Instruction, reports directly to the Dean of Faculty. The Dean of Instruction thus has the ear of the university officer most directly concerned with the quality of the faculty and with departmental practices and standards for hiring, promotion, and tenure recommendations. Hence an organizational mechanism exists for influencing those practices when they are in conflict with the purposes of the Office of Instruction. Obviously, this mechanism must be exercised with considerable skill and political wisdom if it is to be effective. But the point is that it now exists. There is a way for a faculty member to hold the university to account for its claim that innovative teaching is rewarded.

However, accountability applies in both directions. Teachers who expect the support of the Dean of Instruction must be held to account for the quality and effectiveness of their work. For this reason the Office of

Instruction is charged with responsibility for evaluating new educational projects. A mere willingness to experiment is no guarantee of quality or effectiveness; and, if only to protect the credibility of the office, it is essential that the Dean of Instruction distinguish between good work and bad work before making a recommendation to the Dean of Faculty regarding particular faculty members. In this way faculty who work with the Office of Instruction will be under the same kind of tension experienced in a regular department, where they expect support if they do well and not otherwise.

Evaluation, then, is the second way in which the new office will promote effective experiments in education. The third contribution is technical and informational. Physical resources, including standard audio-visual equipment, are being expanded and the staff increased. The campus will be linked with TV cable and more origination and playback equipment will be added. Inexperienced faculty members will find technical assistance.

The fourth activity of the Office of Instruction is to coordinate its educational goals with the purposes of the computer center. Not surprisingly the majority of educational technology projects at Dartmouth have been and are likely to continue to be based on some aspect of computer use. Hence it is essential that a proposed project be examined for additional demand it will place on computer resources, for example. Fortunately, the primary mission of the Dartmouth computer center is to serve educational needs; there is no conflict of purpose with the Office of Instruction. One wonders, however, how many other universities can make that claim.

The final role to be played by the new office is that of fund raiser. It is currently assisting faculty members in four different departments in gaining foundation support for specific projects dealing with educational technology. Its success in this regard can be expected to give the Office of Instruction considerable political leverage when the time comes to speak out for faculty members who have carried out projects under its auspices.

While it is premature to report results for the Office of Instruction, the basic organizational structure is sound. It is the best way developed to date to promote experimentation in education within a traditional university, using regular students and faculty with expertise in regular academic disciplines. If successful, it will not be an isolated institute for educational research, but a practical model for fostering and managing educational change across an entire university.

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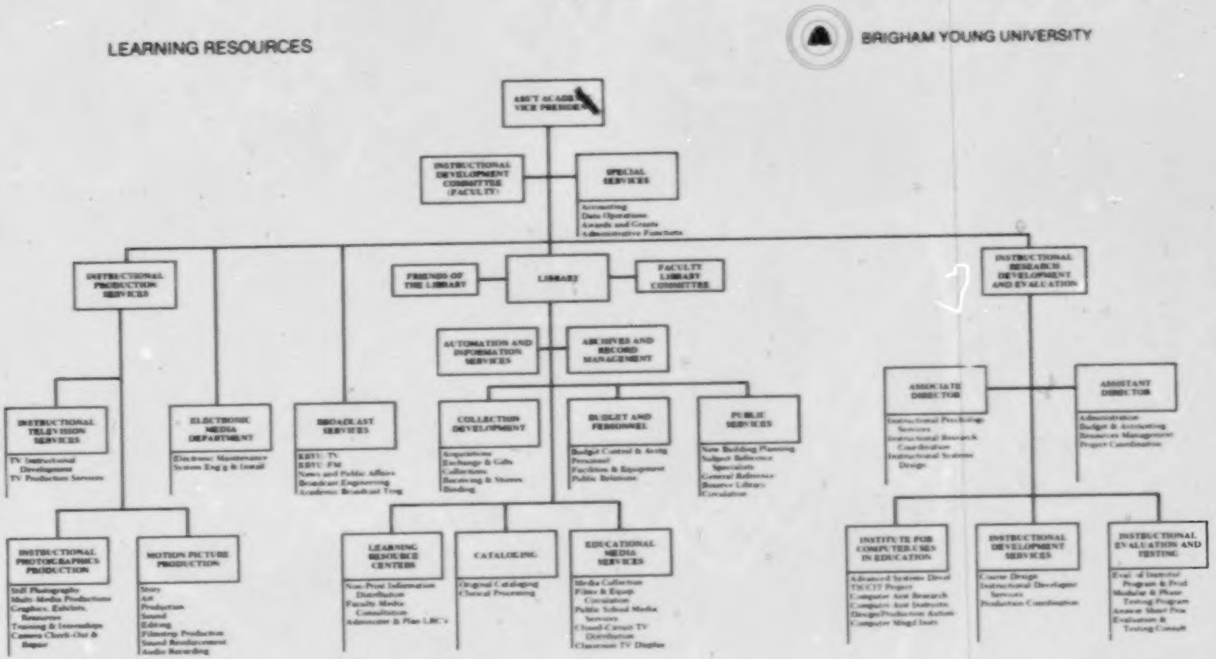
# One Organization for Educational Change

by C. Victor Bunderson

The Learning Resources Area at Brigham Young University, diagrammed in Figure 1, is headed by Darrel J. Monson, an Assistant Academic Vice-President. The program was initiated by Monson in 1965 when he was asked to leave his job as Chairman of the Electrical Engineering Department and take on the responsibility of bringing together, under one centralized agency, all learning resources related to communications then available at the university. At that time Dr. Monson was named head of the Communication Services Division and coordinated an excellent motion picture studio, an excellent television and radio broadcast facility, audio and communications electronics, and various media production facilities and photography. Since 1965 the division has grown rapidly with the biggest growth occurring in two areas. First, a group of research and development-oriented departments was organized starting with an Instructional Research & Development Department headed by Dr. David Merrill. The Institute for Computer Uses in Education was added in 1972. In 1973 the Department of Instructional Evaluation and Testing was added and took over the testing services which had then been a separate administrative unit. Also in 1973, the Department of Instructional Development was created.

The significance of the Division of Instructional Research Development and Evaluation is that it gives a scientific and research orientation to the program of learning resources. In addition, Dr. Monson continually

Figure 1.


LEARNING RESOURCES
BRIGHAM YOUNG UNIVERSITY
ASS'T ACADE VICE PRESIDE
INSTRUCTIONAL DEVELOPMENT COMMITTEE (FACULTY)
SPECIAL SERVICES
Accounting
Data Operations
Awards and Grants
Administrative Functions
INSTRUCTIONAL PRODUCTION SERVICES
INSTRUCTIONAL TELEVISION SERVICES
TV Instructional Development
TV Production Services
INSTRUCTIONAL PHOTOGRAPHICS PRODUCTION
Still Photography
Multi-Media Productions
Graphics, Exhibits, Resources
Training & Internships
Camera Check-Out & Repair
MOTION PICTURE PRODUCTION
Story
Art
Production
Sound
Editing
Filmstrip Production
Sound Reinforcement
Audio Recording
ELECTRONIC MEDIA DEPARTMENT
Electronic Maintenance
System Eng'g & Install
BROADCAST SERVICES
KBYU-TV
KBYU-FM
News and Public Affairs
Broadcast Engineering
Academic Broadcast Trng
FRIENDS OF THE LIBRARY
LIBRARY
FACULTY LIBRARY COMMITTEE
AUTOMATION AND INFORMATION SERVICES
ARCHIVES AND RECORD MANAGEMENT
COLLECTION DEVELOPMENT
Acquisitions
Exchange & Gifts
Collections
Receiving & Stores
Binding
BUDGET AND PERSONNEL
Budget Control & Acctg
Personnel
Facilities & Equipment
Public Relations
PUBLIC SERVICES
New Building Planning
Subject Reference Specialists
General Reference
Reserve Library
Circulation
LEARNING RESOURCE CENTERS
Non-Print Information Distribution
Faculty Media Consultation
Administer & Plan LRC's
CATALOGING
Original Cataloging
Clerical Processing
EDUCATIONAL MEDIA SERVICES
Media Collection
Films & Equip. Circulation
Public School Media Services
Closed-Circuit TV Distribution
Classroom TV Display
INSTRUCTIONAL RESEARCH DEVELOPMENT AND EVALUATION
ASSOCIATE DIRECTOR
Instructional Psychology Services
Instructional Research Coordination
Instructional Systems Design
ASSISTANT DIRECTOR
Administration
Budget & Accounting
Resources Management
Project Coordination
INSTITUTE FOR COMPUTER USES IN EDUCATION
Advanced Systems Devel
TICCIT Project
Computer Asst Research
Computer Asst Instructn
Design/Production Autom
Computer Mngd Instr
INSTRUCTIONAL DEVELOPMENT SERVICES
Course Design
Instructional Developmt Services
Production Coordination
INSTRUCTIONAL EVALUATION AND TESTING
Eval. of Instructnl Program & Prod
Modular & Phase Testing Program
Answer Sheet Prn
Evaluation & Testing Consult

attempts to upgrade and maintain high professional standards and professional activity in the staff of the production services and broadcast services area. One of the more significant aspects of the Division of Instructional Research Development & Evaluation is the graduate program conducted in cooperation with the Educational Psychology Department in the College of Education. This program is based on the assumption that budding instructional psychologists should have an internship consisting of experience on instructional development research and evaluation projects which the service activities of the division provide. Graduates from the BYU Instructional Psychology program have met with considerable success in obtaining good jobs, particularly in university-wide curriculum development and research centers in medical and dental schools and in military training.

Although granting its degrees through the Educational Psychology Department, the Instructional Psychology Doctoral program is interdisciplinary in nature and faculty in the program would like to see this made more explicit through an organization separate from any single college.

The largest area which has been added to Learning Resources, changing its status from that of a division to that of an area under the Academic Vice-President, was the University Library with all of its associated services. Brigham Young University has experimented with, and installed for operational use, a number of learning resources centers all over campus. The Educational Media Services Department of the library distributes thousands of movies, film strips, and other media both on campus, to other campuses of the church educational system, and to congregations of the Church of Jesus Christ of Latter-day Saints throughout the world. Thus the library is a dissemination agency for educational materials in any form.

With the addition of the library, the combined strengths of the original Communications Services Division (later titled the Instructional Services Division) and library services numbers about 700 employees. The magnitude of this investment by a private university is unique. Despite the fact that, with 25,000 students, Brigham Young University is the largest private religious institution in the country, it could not support this operation for its own campus. Through the commitment of the Church of Jesus Christ of Latter-day Saints to innovation and technology in instruction through the program of the church Brigham Young University has become a center for educational innovation. The world-wide church with its own programs of welfare, health services and education throughout the world, and with rapid growth in Latin America and Asia and other areas where Church members need extensive health education and welfare services, calls upon the learning resources area for considerable production and development of instructional materials. This additional extensive service activity justifies the large investment.

## INSTITUTIONALIZING EDUCATIONAL CHANGE

Within the University the greatest current hope for institutionalizing educational change and for the capabilities of the learning resources area to broadly influence the undergraduate program is an extensive analysis and reform of general education which has been going on since 1972. Headed by the Dean of General Studies, a capable young philosopher, C. Terry Warner, and coordinated by a council of some of the strongest scholars at the university, the General Education Program, as now outlined, has laid down as a fundamental principle the separation of evaluation and instruction in the first skill-oriented group of general education requirements. The Department of Instructional Evaluation and Testing will be involved in the administration of the tests which will access skills in reading, speaking, listening, and numeracy, among others. In order to pass these tests students have to take no courses if they do not feel that it is necessary. A substantial learning resources capability is planned to provide laboratory-oriented instruction for students in these basic skills which will be separate from any existing department. Freshman English courses and similar introductory courses will no longer be offered by the regular departments.

Principles used in the development of the administrative structure for educational change at Brigham Young University may be of value to other universities.

- *The areas of Instructional Production, Distribution and Instructional Research Development and Evaluation are all necessary and require separation from existing colleges and departments in high level administrative support.* It is not necessary that they be separated as separate divisions as at BYU.
- *The association of a doctoral program with instructional development research activities is necessary* to give a learning resources area academic respectability and to keep it from becoming a craft shop which can become self-serving.
- *A doctoral program in instructional research development or evaluation needs an internship* in which the doctoral students are confronted with real world projects. Otherwise their dissertations gravitate toward the irrelevancy of much of academic learning psychology.
- *A team relationship must be established with adequate funding between the instructional designers, developers and subject matter experts who are teachers* in the academic units of the university to accomplish viable and self-sustaining instructional development. Furthermore, the interface between the administrative learning resources area and the academic departments requires continual

attention to develop new incentives both for the professionals within the learning resources area and for the faculty members whose reward system usually lies outside of instructional development.

# The Problem of Institutionalizing Educational Change

**by Joseph I. Lipson**

In considering the problem of institutionalizing educational change, the dominant relevant feature of the academic setting is the extent and complexity of the large social system with which one must deal. Colleges and universities recruit from that society and pass students on to that society. While knowledge produced by and located within universities has effects upon society, society's decisions and values affect these institutions, and that society pays for the academic enterprise. To further complicate matters the characteristics and the important variables of the academic system are not all obvious. For example, there may be a pre-selection of personality types who enter academic life which will require different rules for institutionalization in colleges than in the society at large. Colleges are unique kinds of organizations and an analysis of educational change should take this into account.

## THE PROCESS OF INSTITUTIONALIZATION

Institutionalization of educational change has taken place when the change survives the departure of its initiator and becomes a stable part of the system. Local institutionalization would require stability only in the originating institution. For example, the work-study program at Antioch College was institutionalized in a few institutions without (until recently) having much of an impact upon higher education in general. However, national, non-local or extra-local institutionalization requires a certain rate of diffusion and spread to new sites. Change may be institutionalized by: creating a new procedure or a new agency; a complete revamping of a college; any other significant or important change such as development of pass-fail grading or interdisciplinary programs, alternation of requirements, introduction of significant new technologies, the British Open University, and so on. Some of the markedly different paths to an innovation or change in educational practice will be discussed in detail.

*New institution.* One path is the development of an entirely new institution to embody the change. Supposedly this avoids the wrenching effects and barriers to change associated with the modification of an existing institution[1]. Another path involves implementing "the idea whose time has come." In this case, a concept which once seemed impossible to implement, like pass-fail grades or a university ombudsman, gradually, over a period of years, permeates one institution after another as new professors with different beliefs and attitudes participate in decisions.

*Retirement of opponents.* Someone once said of the process of acceptance of new physics theories such as quantum mechanics and relatively that people who held the old ideas were not convinced, they simply die off. Thus the advance of acceptance hinged more on generational change than on the ability to convince people by the evidence at hand. In changes such as legalized abortion, abolition of capital punishment, legalization of marihuana and so on, one can see similar effects. The older people in many survey samples are against change and the younger people are overwhelmingly in favor.

*Time scales and phasing.* An important consideration in institutionalization is the time scale over which the change is to be implemented. By planning for innovation in phase with what seem to be natural time scales for innovation, one may be more successful.

*Authority.* The Flexner report on medical education, the Conant reports on the need for comprehensive high schools, and the Newman reports on higher education illustrate another path to institutionalization of educational change which requires: a prestigious, academically acceptable analysis; and a relationship to either professional power, legislative power, or sources of money. Such reports can also make legitimate an idea whose time has come[1].

*The strong leader.* A college president, a dean, or a department head can generate certain kinds of institutionalized change. At least, leader generated change has been a frequent occurrance over the history of higher education[2]. However, current trends indicate that this approach is becoming more difficult as the force of authority is weakening. In general, faculties are more conservative than administrative leaders. Furthermore, because small budget growth is responsible for a low current rate of faculty turnover, the rate at which young faculty sympathetic to innovation can be recruited is restricted. Prospects and strategies for institutionalized reform are probably more restricted in 1974 because of the small number of places for new faculty members and the decline of the force of authority of central administrators. As a result, universities must look to other routes for institutionalization of change: generation of new institutions; grass roots consensus building; selective compelling demonstrations through social experiments; change through control of the entry of students into advanced levels; and research into the process of institutionalizing change in colleges.

*Complexity.* The social systems involved are very complex. If a medical school tries to change its structure to emphasize a more integrated approach to human health, and if the students then do not do as well on the national exams, there is powerful pressure to revert to the old curriculum. If an innovation requires the development of a new department or agency within a college, boards of higher education or other colleges and departments which may fear competition for students and funds may seek to control the decision. A new approach to engineering may be pioneered but if the graduates have difficulty finding employment, the approach will have been effectively vetoed by the hiring decisions of industry. If parents feel that a more open approach to grades and courses dilutes what they believe is sound educational practice, a school is apt to find itself in sudden economic difficulties. Education and society are so intricately intertwined that change in one system depends upon a complementary change in the other system.

In order to deal with complexity within a college system, one approach calls for the management of change by a single person. If a group of people, each with primary responsibilities elsewhere, is expected to give birth to an innovation, it is probable that some important interactions will be ignored and the innovation will die as the group loses its momentum and the individuals turn back to their primary tasks. On the other hand, if a single individual has the responsibility, that person will more likely be sensitive to present and future opposition, key people to be consulted, needs for money, formal approval of various kinds, and so on. The person in charge, however, must have qualities which may not easily be found and matched to the leadership role.

*Variables and forces.* One important variable is related to whether the change requires active or passive acceptance. Also important is the number of people who must accept a change. For example, faculty may feel strongly about co-ed dormitories, but since most of the faculty do not need to change their way of teaching because of the rooming arrangements, the change only requires passive acceptance. On the other hand, if educational technology is to be widely used on a campus, a much more active and willing participation by faculty and students is required if it is to succeed and survive.

Another important variable in educational change is the nature and amount of capital investment and ongoing expenses involved. Except for capital investment in buildings, educational administration has not learned how to make decisions about capital investments. Yet the availability of resources, human and monetary, is a strong limiting factor on the institutionalization of change.

The variable which exerts the most direct positive pressure for change is the flow of students. If enrollments fall, faculty may respond by accepting strongly advocated innovations which were rejected when times were good. The menu of change may be examined and re-evaluated to seek approaches which promise to attract and hold students. Unfortunately, there is no guarantee that the analysis will avoid the superficial and oversimplistic character of many discussions on the nature of the educative process.

A clearly perceived ideology or powerful analogy is another force for institutional change which is illustrated by the impetus the open or free school idology has provided for new approaches. Dr. Luehrmann's analogy of the computer resource as the modern analog of the library has a similar promise. However, the power of the concept must be matched by comprehension and response on the part of the people who must accept and act upon the idea. The analogy of impedance matching from electronics may be useful in understanding institutionalization of educational change. If one wants to effectively deliver power from a stereo amplifier to the speakers, the impedance of the output of the amplifier must match the impedance of the speakers. The analog of the impedance of the amplifier is the ability of the leader or teacher to formulate a particular kind of meaningful exposition and the ability of the student or follower to comprehend the message. Thus the act of institutionalizing an innovation has many aspects of teaching. The teachings and parables of Christ are a powerful example of impedance teaching. Many of the events of the attempts to implement Dewey's ideas on education can be explained by the impedance matching analogy.

Additional aspects of institutionalization are: the short and long term aspects of the change; the fact that the change may be good for some and not for others; and the uncertainty of the results of the change. These aspects of a proposed change properly introduce a political dimension into the management of change which in turn raises questions of timing, consultation, and general decision making procedures.

Certain kinds of innovation require a period of leader-controlled development in order to preserve the clean character of the concept. However, it is often difficult to obtain this degree of autonomy for an innovation since the individuals involved must each give some form of informed consent to the enterprise. Thus the political dimensions, the ability of the innovative staff to project certainty and confidence and to rally support on key issues, and so on, all become very important in the early stages of a development. The development of the Keller Plan is an interesting case for analysis on this score.

Because all innovations are not positive, other problems occur. Educational administrators often have great difficulty killing a bad innovation or even distinguishing good ones from bad ones. An innovation can properly consist of disposing of a traditional practice. Thus the analysis of institutionalization should tell university administrators: how to admit mistakes; how to undo mistakes of the past; and how to recognize when once serviceable agencies are no longer useful.

*Diffusion of ideas.* Initially, there is a period in the growth of an idea during which a few scattered individuals can recognize and discuss the concept. Usually informed by a professional communication network in which publications and perhaps professional meetings play an important role, these individuals talk to their friends and colleagues about the new idea and, depending upon the interest and urgency of the problem with which the idea deals, these people in turn diffuse the idea to others. Thus colonies of people who know about the idea gradually grow around the initial source. Eventually, the colonies of informed people begin to overlap.

When colonies overlap the percentage of informed people in the society or institution may still be relatively small. However, the concept is sufficiently well known so that one may travel and have a good change of finding people who have discussed the new idea (e.g., Keller Plan, British Open University.) Project COMPUTe is in the early stages of the first phase. The Doctor of Arts program is in the second stage.

At this point it is likely that some form of mass media attention takes over. For example, the editors of *Change, Psychology Today, The Chronicle of Higher Education*, or the education section of *Time*, the *New York Times*, or *Newsweek* will discover that people are all talking about the concept and will prepare a major article or series on the new concept. The leading spokespersons for the new idea will give invited talks at large conventions. The result of this kind of media exposure is that the idea becomes known to most people in the society of interest[1].

Although the concept may become known by name through such mass media attention it may not be accepted. People who have been sensitized to references and arguments relating to the concept will orient themselves positively or negatively toward the idea. The much longer process of reaching consensus for action takes place only after people change attitudes or after people favorable to the innovation acquire the resources and decision making authority to carry out the new idea. A compelling demonstration during a crisis which focuses attention on the ability of the new concept to solve important problems can be decisive. Earlier a demonstration might have gone unnoticed because it had not yet penetrated the consciousness of the relevant public. However, if attitude toward the concept is dependent upon age or social conditions, implementation may have to wait until the older generation retires or until specialized colonies of like minded people can be formed.

During the final stage of development a concept is usually enriched, modified and qualified as it undergoes institutionalization.

At this point the supply of available talent to adequately develop the innovation and develop further talent is crucial. Many programs can grow only as fast as one can train new talent or retrain individuals to adequately fill new roles and perform new tasks. To deal successfully with this phasing problem, money should not be supplied faster than it can be used and people should not be recruited in greater numbers or at a greater rate than they can be adequately introduced to the innovation. Each step of an innovation depends upon processes executed over time by groups of critical size. While planning and the use of technology may shorten many steps and increase the rate at which new people can be trained, the steps cannot be eliminated.

We can also have such phenomena as false failures in which an idea is tried and rejected because it is not properly understood or properly implemented. Jack Getzels of the University of Chicago has said that this is a particular danger in education, that it takes 20 years to recover a good idea which is poorly implemented.

Many of the elements of institutionalization are initiated intuitively or are carried along by traditional processes of organizations without much planning although there is enough knowledge to attempt more comprehensive planning. If innovators don't allow the process of diffusion to occur, they may run the risk of being frustrated because the necessary social processes must take place over time. Very few administrators have the social and political clout to introduce an innovation on a massive scale through reputation alone.

## THE D.A. AT CHICAGO CIRCLE

The Chicago Circle Campus of the University of Illinois was established in 1965 when the demand for Ph.D.'s was expected to continue to be strong for some time, and people came to the faculty with every expectation of having Ph.D. programs in all major areas. However, before this expectation could flower into fulfillment, the freeze hit higher education and, in 1972, Chicago Circle which had grown from nothing to 19,000 students suddenly found its growth traumatically restricted.

As growth leveled off more faculty began to look for appropriate ways for the campus to develop new programs in spite of the new restrictions. Jan Rocek, Dean of the Graduate College and a chemist, was anxious to develop new graduate programs. At the same time, the Chemistry

Department had huge enrollments in the entering courses but there was severe attrition due to inadequate student preparation. The Chemistry faculty concluded that newer approaches were needed and could be developed within the context of a program leading to the Doctor of Arts degree.

As a result of early conversations, Dean Jan Rocek convened a Doctor of Arts Faculty Committee. With some dissent, the Committee reported out a set of guidelines and recommendations which became the major blueprint for the Doctor of Arts program at the University of Illinois at Chicago Circle. Because faculty members were afraid that the new degree was being forced upon Chicago Circle in place of the Ph.D. degree, and for some other reasons, the faculty agreed that the D.A. would not be accepted into any department that did not also have a Ph.D. degree. Another reason offered for this move was to assure that the quality of the D.A. departments would be of the same quality as that required to give a Ph.D. degree.

The departments involved in the Doctor of Arts degree were: the Chemistry Department, under the leadership of Professor Kotin and with the support of Professor Sage; the Math Department with Professors Feinstein and Landin; the Physics Department with Professors Kouvel and Sundaram; the Biology Department with Professors Shapiro, Bardack and Hadley; and the German Department with Professors Shaw and Heitner.

It is important to note that the University demonstrated commitment to the new program by finding the money to hire an Associate Dean of the Graduate College with primary responsibility of developing and promoting the Doctor of Arts program. At that time, even though the committee report had been released, no department had yet had a Doctor of Arts proposal approved by the Board of Trustees or by the Board of Higher Education of the State of Illinois which had clamped a moratorium on all new doctoral programs. The Graduate College sought $300,000 in external support over a three year period in order to hire special faculty to develop new courses for the program and to supervise the work of D.A. students. Money was also sought to support students and student projects in the program. However, granting agencies were reluctant to award funds for a program which had not been approved by the State Board of Higher Education because such grants might give the appearance of trying to apply pressure to the decision making process at the local level.

Although the faculty report from a multi-departmental group required quite definitely that a core faculty of the Doctor of Arts program should have a strong voice in the education and thesis work of the Doctor of Arts graduate students, many faculty members feared that the extra-departmental components would re-create a new department of education, and any steps which seemed to lead in this direction were resisted. As a result of these concerns, a Doctor of Arts Committee was formed with representation from all the departments which had a strong interest in the Doctor of Arts program. Many times it seemed that it would be impossible to satisfy all the groups which had a veto power over the program, as those faculty and administrators who were committed to the program were simultaneously negotiating with faculty, department heads, the D.A. Committee, the university administration, funding agencies, the State Board of Higher Education and the PLATO group at Urbana.

The simultaneous strategy began to pay off when the National Science Foundation with Dr. Alice Withrow as the program officer, the Sloan Foundation represented by Dr. James D. Koerner, and the Carnegie Corporation represented by Dr. E. Alden Dunham all showed interest on the condition that some accommodation could be made with the Board of Higher Education. Even before formal state board approval of the D.A. was obtained, faculty were able to obtain approval from the Director of the Board's staff to submit funding proposals for a modified Ph.D. program which had the requirements but not the name of the D.A.

Grants from prestigious foundations, first the NSF, then the Sloan Foundation and the Carnegie Corporation, gave the program a tremendous lift. Furthermore, since the grants funded the extra-departmental activity, this critical component was strengthened. The support from symbols of power and authority in the academic world gave legitimacy to the program design.

Although administrators sought the approval of the faculty D.A. Committee for all key decisions at every step, there were still fears that the administrators might subvert the wishes of the faculty. In particular, faculty approval was difficult to obtain for the hiring of new faculty for computer-based education and for the design of natural experiments and evaluation of educational effectiveness. A candidate for a faculty position had to be approved by the faculty, the department heads of the concerned departments and the faculty of the departments in which the new member would hold or seek tenure. Because D.A. faculty members were also hired as hard positions even though they would temporarily be paid from grant funds, the hiring process was in deadly earnest. However, because of the different perspectives of different people and different departments, it was nearly impossible to agree on whom to hire. It was frustrating to see excellent candidates enthusiastically accepted by one group only to be totally rejected by others.

Before any new faculty had been successfully hired, the Board of Higher Education approved the Doctor of Arts program in Chemistry and Mathematics. At the same time the project director became an Associate Vice Chancellor which assured the program a voice in the administrative council.

Another important move was the appointment of Dr. James Norr as Acting Associate Dean of the Graduate College and coordinator of the

D.A. program. Dr. Norr is a young assistant professor in the Sociology Department with a major research interest in methods of teacher evaluation. Because the only sure path to tenure at Chicago Circle is a strong research record, Dr. Norr made a daring and valuable move in accepting the appointment.

Under Dr. Norr new D.A. faculty have been hired, the first students have entered the program, and the first courses have been offered. Interestingly, initial D.A. courses have been over subscribed and have enrolled Ph.D. as well as D.A. students.

## FACTORS IN INSTITUTIONALIZATION

It is premature to say that the Doctor of Arts program has been institutionalized at the University of Illinois at Chicago Circle. To be a true success it must outlast Dean Jan Rocek, Department Head Bill Sager, Professor Leonard Kotin and Associate Vice Chancellor Lipson. Further, it must spread to other major universities if it is to do the job which needs to be done.

What factors contributed to the successful beginning? First, the program was pushed by a highly respected and outstanding scholar, Graduate Dean Jan Rocek, which assured academic respectability for the degree.

Second, faculty of the concerned departments were kept in charge of the major decisions. Now that faculty have been hired specifically to teach in the D.A. program, it has individuals with a sustaining interest to spread and advance the program.

Third, considerable planning went into the program so that a great many pitfalls were worked out and thought out ahead of time. The planning was not perfect but it laid the groundwork for convincing argument when debates became serious.

Fourth, the ability of the program to attract significant outside support was a powerful factor at a critical time. Access to the PLATO program also gave the program the charisma of a new system with exciting potential.

Because outstanding research workers in the Chemistry Department have taken an active and sustained interest in the program, this pattern has a good chance of holding in other science departments. The program also offers the promise of dealing with significant problems which face most science departments.

Because the program has been supported by several national groups of stature and by respected individuals such as Dr. Paul Dressel and Dr. E. Alden Dunham, it has been more easily accepted by Chicago Circle faculty. Finally, the program addresses a general need to improve the teaching and communication of knowledge.

What may cause the downfall of the D.A. program? It is difficult to build and sustain a foreign body in a host. It is not clear that the graft of the D.A. program will take in the face of suspicion and uncertain payoffs for faculty and administrators. Because the forum for the research effort which must be associated with the new degree has not yet been established and because the proposed research methodology is both difficult and expensive, the research component may be difficult to institutionalize within the disciplines.

However, the program can grow slowly and still wind up as a success in the long run.

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# PART V

## BANQUET ADDRESS

# Chapter 21

## Computing Applications in the USSR

by D. Don Aufenkamp

### INTERNATIONAL COOPERATIVE ACTIVITIES

The National Science Foundation[1,2] encourages and supports U.S. scientific participation in international science programs and activities that promise maximum benefit to the U.S. science effort. These activities are broad and diverse. In 1973 the foundation served as the executive agency for a dozen bilateral agreements and is active in developing cooperative science programs in several other areas as well. Only a few examples include: the U.S.-India Exchange of Scientists Program; the U.S.-Italy Cooperative Science Program; the U.S.-Israel Binational Science Foundation; the U.S.-Latin America Cooperative Science Program; and the support through the NAS of the International Institute for Applied System Analysis in Austria. IIASA is a multinational research center involving the U.S., the U.S.S.R. and several other countries.

During the past year the foundation assumed a major role in the development of cooperative programs between U.S. scientists and their U.S.S.R. counterparts. The Director of the NSF, Dr. Guyford Stever, was appointed U.S. Co-Chairman of the Joint Commission for the U.S.-U.S.S.R. Agreement on Cooperation in the Fields of Science and Technology. This bilateral agreement with the U.S.S.R. is but one of eight such agreements although most of them have U.S. agencies other than the NSF as the executive agent. Other agreements include ones in agriculture, medicine, oceanography, environment, space, energy and transportation.

## US-USSR AGREEMENT ON SCIENTIFIC AND TECHNICAL COOPERATION

The U.S.-U.S.S.R. Agreement on Scientific and Technical Cooperation was signed in Moscow on May 24, 1972, during President Nixon's visit. Under this agreement both countries pledge themselves to assist and develop scientific and technical cooperation between both countries on the basis of mutual benefit, equality and reciprocity. The main objective of this cooperation is to provide broad opportunities for both countries to combine the efforts of their scientists and specialists in working on major problems, whose solution will promote the progress of science and technology for the benefit of both countries and of mankind.

Under the agreement, a joint commission was established which meets annually alternately in Moscow and Washington. The most recent meeting was held in Moscow in November 1973. Cooperative programs are being developed and implemented in twelve areas thus far including: chemical catalyses; the production of substances by microbiological means; science and technical information; water resources; forestry research and technology; and electrometallurgy.

In one of the areas, the application of computers to management, management is given a very broad interpretation. I am Chairman of the U.S. side of a Joint Working Group established by the joint commission. My counterpart is Dr. B. I. Rameev of the State Committee of the U.S.S.R. Council of Ministers for Science and Technology. Dr. Rameev is well known within the Soviet Union for his work on the design of the URAL series of Soviet computers. Together with other specialists from both countries, the joint commission has devoted a major effort during 1973-74 to developing a program of mutual benefit satisfactory to both sides.

Three topics have been defined in detail and implementation is underway:

- Econometric modeling (development of forecasting models for analysis of various branches of the economy);
- Computer analysis applied to the economics and management of large systems; and
- Applications of computers to the management of large cities.

Two other topics are being developed:

- Theoretical foundation for software for application in economics and management; and
- Computer-aided refinement of decision-making of high level executives.

The emphasis is on computer applications not on computer science and technology as such although, of course, it plays an underlying role.

Travels of the working group members thus far have included: some

20-30 different organizations in a half dozen cities, Moscow, Leningrad, Kiev, Tbilisi, Sukhumi, and Novosibirsk; and visits with several dozen researchers, administrators, city and government officials. Nevertheless, participants have seen only a very small part of the U.S.S.R. A total of about two months has been spent in the U.S.S.R. and about half that much time working with Soviet delegations in the U.S.

## SOVIET COMPUTING APPLICATIONS

At least in their thinking and planning for the coming decades, computer-based systems are destined to play a central role. These systems, too, are no ordinary systems. In the Directives of the 24th Congress of the Communist Party of the Soviet Union, Mr. A. N. Kosygin noted, "Our planned economy permits the creation of a state-wide automated system for collection and processing of information for accounting, planning, and national economic management on the basis of a state system of computer centers and a unified automated communications network."

Descriptors like unified, universal, integrated, networks, automated, hierarchical, closed-loop, total systems, all are heard in connection with planned or proposed systems. Thus, for example, in response to Mr. Kosygin's remarks, there is the Statewide Automated Management system which will be based on the State Network of Computer Centers and the Statewide Data Transmission System. The purpose of the Statewide Automated Management system is to improve planning and management on the basis of widespread use of econometric methods, computer technology and communications facilities. The system must provide needed guidance information to statewide, republic, and territorial management organizations, to ministries and departments, for the solution of problems of accounting, planning, and decision-making in the area of economics and production.

This is a very ambitious goal. The difficulty, of course, is not one of describing the objectives at this level, but how to proceed to accomplish these objectives. Among the problems that must be solved somehow in the development of the system, if it is to be effective, are the following:

- analysis of trends in the growth of the overall socialist economy of the country, its union republics (there are 15) and its economic regions; and
- analysis of projects for future and current plans for the development of the economy of the U.S.S.R. and its branches, and also for the development of the economies of the union republics and economic regions, material and technical supply, capital construction, transportation, financial and credit planning, labor resources, price-fixing, etc.

These undertakings are very complex ones and clearly extend well beyond the acquisition and installation of computer hardware and the usual computer software. One has, too, the impression that all too often in both countries the installation of hardware is considered somehow equivalent in effect to having already long-term solutions for these complex dynamic economic problems.

The basis for a large part of the cooperative program has been the emphasis on the methodology of addressing planning problems of great complexity. Both countries, and, of course, the entire world could benefit from an improved understanding of these complex problems.

Within the Soviet Union U.S. participants in the joint working group are developing close ties with institutions responsible for different aspects of this work. There is, for example, GOSPLAN, the State Committee of the Council of Ministers responsible for Planning. In a centralized planned economy as that in the Soviet Union such a group carries much responsibility for developing and implementing the long-range plans like the Five Year Plans. The group is also establishing close ties with the CEMI, Central Economic-Mathematical Institute of the Academy of Sciences, a research institute concerned in large part with research on theoretical solutions to the complex system problems of forecasting for long-term development. A third aspect of this work, which in some ways links the work of CEMI with GOSPLAN, is the research of the Institute of Economics in Novosibirsk which is playing a key role in coupling theoretical developments to the very real and practical problems of developing resources and the associated enterprises in Siberia.

Another topic of cooperation is the application of computers to the management of large cities. The joint commission has spent much time working with city officials in Moscow, Kiev, Leningrad and Novosibirsk. It is important to recognize at the outset that the functions of city government in the U.S.S.R. are vastly different from those in the U.S. Municipalities in the Soviet Union, for example, are responsible for all residential and commercial construction, for operating bakeries, running all retail stores, operating all restaurants, cafes, ice cream parlors, and so on, and for the delivery of all goods, from bread to boots and bricks. The mayor of Moscow ranks among the world's major executives in terms of responsibilities and resources. He directs a work force of 1,400,000 municipal employees in a city with a population of 7.5 million. The mayor of New York is responsible, by comparison, for a work force of less than 400,000 in a city of eight million. One of the city of Moscow's most important computer applications, which reflects local needs, is developing daily delivery schedules and actual truck routes for the transport of goods throughout the city. Twenty million metric tons per year are transported by a fleet of some 60,000 trucks.

One of the more impressive research groups which the group visited in Leningrad was concerned with city management problems.

Lensystemotechnica was formed in 1970 and has 1500 employees. Besides operating current systems for the city, this extremely talented technical unit is enthusiastically engaged in a long-term goal of 10 to 30 years for a "completely automated system for the entire management of the city" to be integrated with corresponding systems at the regional and national levels. City planners in the U.S.S.R. have long-range plans, some stretching 30 years into the future for the complete range of city functions. One interesting aspect of planning, different at least from that in the United States, is the establishment of a "green belt" of trees of ten kilometers or more in width around the major cities is a part of an environmental plan.

In applications to city management, there also appears to be an almost uncritical enthusiasm for total management information systems that parallels a similar wave of optimism that existed in the U.S. some ten years ago. How well these objectives can be met, depends, of course, to some extent on the acquisition of appropriate computer hardware and software. However, the really difficult problems are analytical in nature; to develop forecasting and modeling techniques to assist in understanding the long-range dynamic societal problems faced by municipalities.

## COMPUTER AIDED DECISION-MAKING

The U.S.S.R. is placing a strong emphasis on the task of increasing the qualifications of managers for the purpose of increasing the efficiency of production. This emphasis is also in line with the directives of the 24th Congress of the Communist Party in the current five-year plan on the development of the economy of the U.S.S.R. in the area of improving the methods of management and planning on the basis of widespread use of computer technology and econometric methods.

One of the more interesting institutes visited in connection with developing this topic was the Institute of Economic Management which is organized under the State Committee of the Council of Ministers for Science and Technology. This is a management institute for top industrial managers such as ministers, deputy ministers, presidents and directors of industrial enterprises. The school was created 2-1/2 years ago. Sessions run three months, five days a week, with about 80 in a class currently. There are four principal chairs in the institute:

- social-economic aspects of management;
- economic-mathematical methods of planning;
- social, juridical problems of management; and
- automatic systems.

Throughout, there is an emphasis on a systematic study of the latest achievements of domestic and foreign science and technology, of effective methods of planning and economic stimulation, and of scientific organization of labor and management using computers. The expectation is that in five years there will be 500-600 students per class. The curriculum includes two thesis projects: one thesis on applied economics and mathematics; and one thesis on applied social and psychological aspects. Students are encouraged to write these theses in terms of their own job responsibilities and, in fact, there is a consious follow-up to see how well the thesis is being applied by the student on his or her return to the regular position. Although this last topic has not yet been completely defined, it is one which we believe should be very interesting to both countries, and, of course, will help to make the work in the other areas more useful to all.

This overview hopefully will give some insight into computer applications in the Soviet Union and to the approach being taken under the Agreement for Scientific and Technical Cooperation for developing a program of activities. A few may also give some perspective on the way in which the commission works. Working sessions are described as taking place in an atmosphere of mutual understanding and cooperation with an exchange of views on both sides. The role of the working group is to help to work out the details of scientific recommendations. Working sessions, nevertheless, are far more than formalities. There is, of course, an aspect of formality involved, but for the most part the work has been in the nature of trying to understand the substance and approach being taken by scientists and other officials in both countries and in working out together a plan of action. The sessions are often long and intense. There are problems introduced by the differences in languages, by differences in terminology within disciplines, by differences in approach to scientific research in both countries, and by possible differences in objectives on both sides because it is all being conducted within the framework of the larger political setting.

It is the practice to prepare a communication following major meetings to summarize, for the record and for the joint commission, the work that took place during the meetings. The preparation and wording of these communications, which are written in both the English and Russian languages, is particularly important because they form a sequence of building blocks on which joint efforts rest. Records which have been prepared are available on request to interested individuals.

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# Appendix A

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